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TAXONOMIC CHARTS OF THE MONOCOTYLEDONS AND THE DICOTYLEDONS.

BY JOHN W. HARSHBERGER, PH.D.

(*Read April 19, 1907.*)

At various times botanists have constructed phylogenetic diagrams to show the evolutionary relationship of the various families of plants, but in all of these family trees the attempt has been made to represent the actual evolutionary history of each plant group. Beyond representing the general lines of evolution of the vegetable kingdom, these diagrams, it seems to the writer, do not go. Haeckel in his "Phylogenie der Protisten und Pflanzen" gives elaborate tables to represent the phylogeny of different plant groups, Campbell in his lectures on the "Evolution of Plants" (1899) gives at the close of each important section of his book family trees of the algæ, fungi, mosses, ferns and flowering plants. Bessey[1] in 1897 discussed before the Botanical Society of America the phylogeny and taxonomy of the angiosperms, while Engler in *The Botanical Gazette* in May, 1898 (pp. 338–352), discusses the taxonomic division of the spermatophytes, as an abridged treatment of the same subject in Parts II., III. and IV. of the supplement to his "Die natürlichen Pflanzenfamilien." Bonnier and Sablon give useful

[1] Bessey, Charles E., "The Phylogeny and Taxonomy of Angiosperms," *Botanical Gazette*, XXIV (1897).

tables of taxonomic relationships in their large text-book of botany ("Cours de Botanique Phanerogames").

Bearing upon this same field of botanical speculation and investigation, a number of important papers have appeared which approach the subject from the morphologic and histologic sides. Curtis in his "Text-Book of General Botany" (1897) conjectures the nature of the affinities of monocotyledons and dicotyledons, stating that the monocotyledons may be considered as a branch that has departed from the dicotyledonous type and become structurally weak owing to their aquatic habitat. He also gives a short statement of the evolution of the flower and of floral types. One of the most interesting theories regarding the evolution of the higher flowering plants is one proposed by Balfour[1] on the philosophy of water and vegetation. In this paper, Balfour traces the evolution of the types which being exposed to the failure of water show consequential difficult movement of the sperm cells and, therefore, have adapted themselves gradually to a dry environment by the development of flowers and true seeds. Campbell[2] describes the causes that led to the general abandonment of the aquatic habit and the adoption of a land habit, which characterizes the predominant plants of the present time. The adoption of the seed habit, according to Scott,[3] gives the plant possessing such a habit the following advantages:

1. Pollination on the parent plant, and consequently greater certainty in bringing together the two kinds of spores.

2. Fertilization either on the plant or at least within the sporangium giving greater certainty of success and protection at the critical moment.

3. Protection of the young prothallus from external dangers.

Rendle in the *New Phytologist* (II:66, 1903) considers the origin of the perianth in seed plants, and later in 1904 in his book the "Classification of Flowering Plants" traces the affinities of the

[1] Balfour, Prof. I. Bayley, "Philosophy of Water and Vegetation, *Nature*, 64: 557, October 3, 1901.

[2] Campbell, D. H., "The Origin of Terrestrial Plants," *Science*, n. s., XVII: 93, 1903.

[3] Scott, D. H., "Origin of the Seed Habit," *Nature*, 68: 377–382, 1903.

gymnosperms and the monocotyledons in a clear and lucid manner. Ethel Sargant[1] from detailed macroscopic and microscopic studies of a large number of seeds and seedlings describes the dicotyledonous seedlings that show a well-marked cotyledonary tube, thus suggesting the origin of monocotyledons from a dicotyledonous stock. She gives a complete bibliography of the more important articles that have recently appeared on the subject, mentioning the work of Lyon on the embryogeny of *Nelumbo* and Holm on *Podophyllum peltatum* and *Erigenia bulbosa*. Harris[2] in a short article gives a brief, but useful, resumé of the attitude of modern botanists on the origin of monocotyledons from dicotyledons. Coulter and Chamberlain believe that the phylogeny of the angiosperms will always remain a baffling problem. They believe that there is not sufficient evidence of the monophyletic origin of monocotyledons and dicotyledons as claimed by Jeffrey, Queva, Sargant and others. They believe that the facts are strongly in favor of an independent origin of both monocotyledons and dicotyledons.

Having briefly reviewed the current theories concerning the origin and taxonomy of the angiosperms, it falls to the lot of the writer to describe the taxonomic charts which accompany this account. In the arrangement of the dicotyledonous and the monocotyledonous families, the plan has been adopted of showing the generally recognized affinities of the different groups, rather than absolutely relying on the proven natural descent, or evolutionary relationship. Wherever that descent has been established definitely by botanical investigation, it has been incorporated in the accompanying charts. Absolute affinity is an extremely difficult matter to determine in families of such widely diversified structure. It is important, however, to have some phylogenetic scheme which will picture in a diagrammatic way the supposed relationship of the numerous plant families. Such diagrams, the author believes, will greatly assist in the future investigation of the morphology, embryology and phylogeny of the flowering plants.

[1] Sargant, Ethel, "Theory of the Origin of Monocotyledons founded on the Structure of their Seedlings," *Annals of Botany*, XVII: 1–92, Jan., 1903.

[2] Harris, J. Arthur, "Monocotyledons or Dicotyledons," *The Plant World*, VI: 79, Apr., 1903.

In the preparation of the two original charts illustrating the taxonomy of the monocotyledons and dicotyledons, the author has been greatly assisted by Engler and Prantl's "Die natürlichen Pflanzenfamilien," Englers' "Syllabus der Pflanzenfamilien"

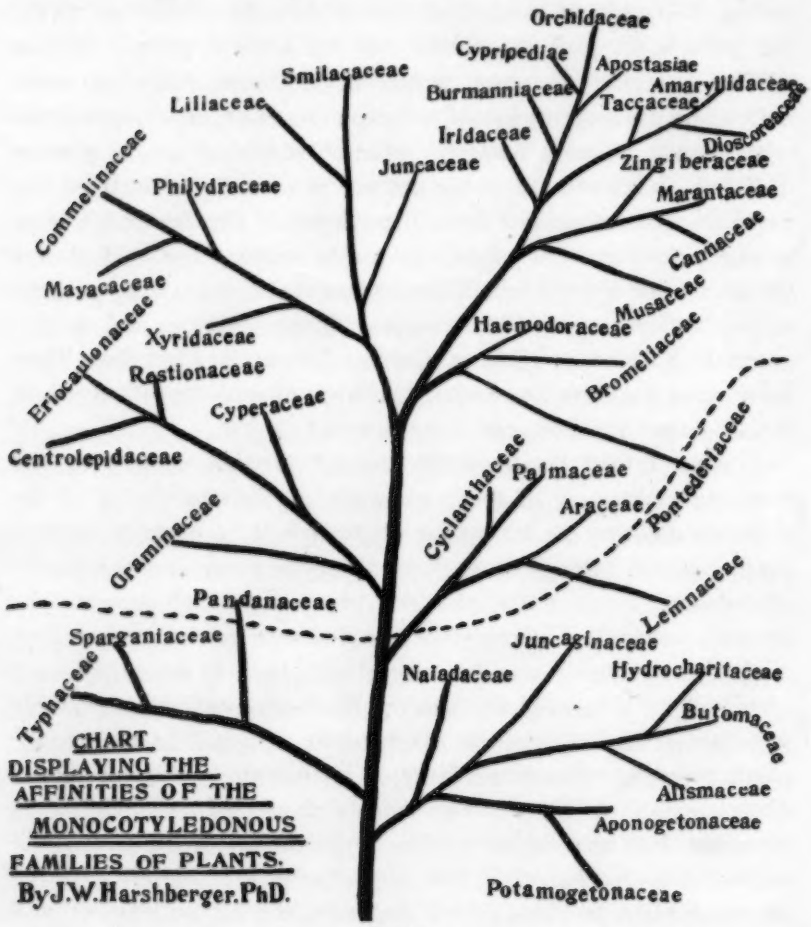

FIG. 1.

(1898), Warming's "Systematic Botany," Le Maout and Decaisne's "General System of Botany" (Mrs. Hooker's translation), Lindley's "Vegetable Kingdom" and Rendle's "Classification of Flowering Plants" (Volume I.).

Referring to the chart illustrating the taxonomy of the monocotyledons, the families may be divided roughly into two groups, the aquatic and terrestrial. Such aquatic orders as Naiadaceæ, Typhaceæ, Sparganiaceæ, Potamogetonaceæ and Aponogetonaceæ are according to the views of the writer undoubtedly primitive. The remarkable male flower of *Naias* in having a terminal stamen, which has either four longitudinal loculi, or one central one, and the female flower with unilocular gynœcium and single erect ovule with pollination under water are no doubt primitive characters. The Butomaceæ and Alismaceæ, as families of the order Helobiales, relate themselves according to some authors with some of the Ranales. And if the Ranales are not highly evolved in structure, having apopetaly and apocarpy, then the Helobic families are comparatively simple for the same reasons.

The families in which the parts of the flowers are surrounded by chaffy scales, namely the Cyperaceæ and the Graminaceæ, are probably not as closely related as was formerly supposed. Some botanists consider that the grass family is to be ranked as a primitive order and not a degraded liliaceous type through the Juncaceæ. This view the author believes is the correct one, and he has, therefore, removed the Juncaceæ from nearness to the Cyperaceæ and placed it as a more primitive form of Liliales with dry, scarious perianth segments. The families with petaloid perianth segments the author has placed on two separate limbs of the family tree. On one limb will be found the families in which the ovary is superior and on the other those families in which the ovary is inferior. Smilaceæ represent the most modified liliaceous type and Juncaceæ the least modified. The Bromeliaceæ, Marantaceæ, Amaryllidaceæ, Orchidaceæ and Iridaceæ, include the most modified types of plants with inferior ovary and are indicated by as many distinct branches of the family tree. Thus from Burmanniaceæ one proceeds to the Orchidaceæ through Apostasiæ and Cypripediæ. The family Dioscoreaceæ includes plants the flowers of which are dioecious forms of amaryllidaceous flowers. Beginning with Musaceæ the series passes through Zingiberaceæ and Cannaceæ to the Marantaceæ, and the botanist finds a strongly marked parallelism of development, the most marked tendency being the petaloid development of the sta-

mens and the style with the reduction of the number of fertile stamens to one.

The Palmaceæ and Araceæ stand off probably, as having affinities with each other, but not closely related to the other petaloideous, monocotyledonous families. Lemnaceæ may be considered to be a modified or degraded form of Araceæ, while the bromeliacèous plants with superior and inferior ovaries show affinities to the Amaryllidaceæ and the Liliaceæ, and hence, the writer has placed the order Bromeliaceæ on a branch near where the two upper limbs of the family tree diverge from each other. The complete liliaceous structure without great reductions in the number of whorls, but with generally few ovules in each loculus of the ovary, is found in the Commelinaceæ, while the Mayacaceæ, as a family, is closely allied to the Commelinaceæ. The Xyridaceæ are marsh plants with radical leaves arranged in two rows and short spikes on long stalks. The flowers, as in Commelinaceæ, have sepals (which, however, are more chaffy) the petals, but the outer series of stamens is wanting. The order Eriocaulonaceæ on another branch is sometimes called the "Compositæ among Monocotyledons" with radical and grass-like leaves, while the habit of the plants of the Restionaceæ is quite similar to the Cyperaceæ.

It is a much more difficult task to trace the affinities of the dicotyledonous families of plants. Roughly we may divide the families into the Incompletæ, the Apopetalæ and the Gamopetalæ. The plants of the primitive Incompletæ are all or nearly all of them provided with flowers that are wind pollinated. Such orders as the Salicaceæ, Myricaceæ, Juglandaceæ, Fagaceæ, Betulaceæ and Corylaceæ are not only wind pollinated, but the staminate flowers are in catkins, thus being advantageously situated for the discharged pollen to be carried away by the wind. The perianth in these orders is absent, or extremely rudimentary. The affinities of these primitive dicotyledons, as the writer has been enabled to determine them, is displayed in the larger of the two accompanying charts.

The apopetalous families in which the petals are absent or distinct are to be regarded as more primitive than the gamopetalous families. The relationship between the families is a group relationship. Thus the Loranthaceæ, Rafflesiaceæ, Balanophoraceæ, Santa-

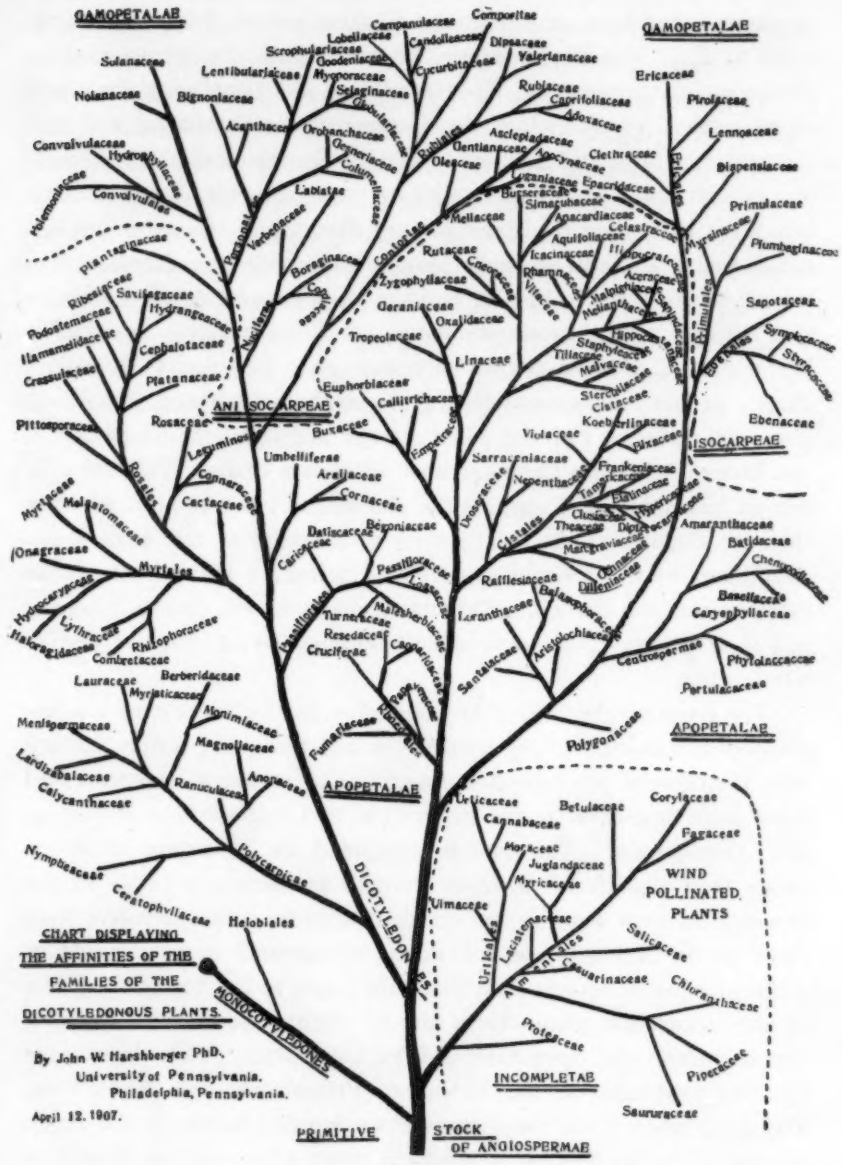
GAMOPETALAE
GAMOPETALAE
Campanulacese
Compositae
Lobeliaceae
Candolleaceae
Scrophulariaceae
Goodeniaceae
Dipsaceae
Valerianaceae
Solanaceae
Lentibulariaceae
Myoporaceae
Cucurbitaceae
Ericaceae
Nolanaceae
Bignoniaceae
Selaginaceae
Rubiaceae
Pirolaceae
Acanthaceae
Globulariaceae
Caprifoliaceae
Convolvulaceae
Orobanchaceae
Asclepiadaceae
Adoxaceae
Lennoaceae
Hydrophyllaceae
Gesneriaceae
Gentianaceae
Cliethraceae
Bipensiaceae
Polemoniaceae
Columelliaceae
Apocynaceae
Epacridaceae
Primulaceae
Convolvulales
Labiatae
Buxaceae
Simaroubaceae
Myrsinaceae
Plantaginaceae
Verbenaceae
Rutaceae
Aquifoliaceae
Plumbaginaceae
Boraginaceae
Cneoraceae
Icacinaceae
Sapotaceae
Ribesiaceae
Saxifragaceae
Zygophyllaceae
Rhamnaceae
Hydrangeaceae
Geraniaceae
Oxalidaceae
Podostemaceae
Cephalotaceae
Tropeolaceae
Linaceae
Hamamelidaceae
Platanaceae
Tiliaceae
Malvaceae
Crassulaceae
Euphorbiaceae
Callitrichaceae
Sterculiaceae
Cistaceae
Ebenaceae
Pittosporaceae
Rosaceae
Butaceae
Koeberliniaceae
Violaceae
Pixidaceae
Leguminosae
Umbelliferae
Sarraceniaceae
Frankeniaceae
Araliaceae
Nepenthaceae
Tamaricaceae
Connaraceae
Cornaceae
Elatinaceae
Cactaceae
Datiscaceae
Begoniaceae
Clusiaceae
Theaceae
Amaranthaceae
Myricaceae
Melastomaceae
Caricaceae
Passifloraceae
Mangraviaceae
Batidaceae
Onagraceae
Myrtales
Loasaceae
Connaceae
Chenopodiaceae
Hydrocaryaceae
Turneraceae
Malesherbiaceae
Resedaceae
Loranthaceae
Balanophoraceae
Caryophyllaceae
Lythraceae
Rhizophoraceae
Cruciferae
Capparidaceae
Aristolochiaceae
Centrospermae
Phytolaccaceae
Haloragidaceae
Combretaceae
Lauraceae
Berberidaceae
Santalaceae
Portulacaceae
Myristicaceae
Papaveraceae
Menispermaceae
Monimiaceae
Fumariaceae
Polygonaceae
Lardizabalaceae
Magnoliaceae
Calycanthaceae
Ranunculaceae
Anonaceae
Urticaceae
Betulaceae
Corylaceae
Nymphaeaceae
Polycarpicae
Cannabaceae
Fagaceae
Ceratophyllaceae
Helobiales
Moraceae
Juglandaceae
Myricaceae
Ulmaceae
Urticales
Salicaceae
Casuarinaceae
Chloranthaceae
Proteaceae
Piperaceae
Saururaceae
CHART DISPLAYING
THE AFFINITIES OF THE
FAMILIES OF THE
DICOTYLEDONOUS PLANTS.
By John W. Harshberger PhD.
University of Pennsylvania.
Philadelphia, Pennsylvania.
April 12, 1907.
ANISOCARPEAE
ISOCARPEAE
APOPETALAE
APOPETALAE
DICOTYLEDONES
MONOCOTYLEDONES
WIND
POLLINATED
PLANTS
INCOMPLETAE
PRIMITIVE
STOCK
OF ANGIOSPERMAE

FIG. 2.

laceæ are grouped together not only because of certain structural characters, but because the plants of these orders show a parasitic habit of life. The Portulacaceæ, Phytolaccaceæ, Batidaceæ, Caryophyllaceæ, Amaranthaceæ, Chenopodiaceæ and Basellaceæ form another natural group, while the Cornaceæ, the Araliaceæ and the Umbelliferæ form still another important branch of the dicotyledonous family tree. The families that by the agreement of most botanists form the order of Rhœdales are Resedaceæ, Cruciferæ, Capparidaceæ, Papaveraceæ and Fumariaceæ, while the families that belong to the Ranal Alliance, and are thus suggestive of the Helobial Alliance among monocotyledons, are Ranunculaceæ, Anonaceæ, Magnoliaceæ, Berberidaceæ, Calycanthaceæ, Lauraceæ, etc. The affinity of the families comprising the order, or alliance, Rosales is also very strong. For the other groups and families, the endeavor has been to associate them together in such a manner that the system of branching will suggest the character of the affinity, whether close or distant. Thus the families at the base of any branch are considered in the scheme to be more primitive than those at the extremity of the branch. The arrangement of the lateral branches and their proximity to each other is suggestive of close or distant relationship.

The Gamopetalæ, which are undoubtedly the highest of the angiosperms, naturally group themselves into two main trunks, having both a different phylogenetic origin. The writer has represented these main branches, at the suggestion of Campbell,[1] as Isocarpeæ and Anisocarpeæ. The families included as Isocarpeæ show an ovary that consists of as many carpels as there are petals in the flower, and such families are considered to be more primitive than those of the Anisocarpeæ, where the syncarpous ovary consists of a less number of carpels than there are petals to the flowers. A few of the isocarpous plants have almost distinct petals and to some extent connect the Apopetalæ and the Gamopetalæ. The isocarpous families culminate in the Ericaceæ, Primulaceæ and Styracaceæ. The great majority of the gamopetalous families belong to the anisocarpous division, the less specialized types with regular tubular or funnel-shaped corollas being the morning glories (Convolvulaceæ),

[1] Campbell, D. H., "The Evolution of Plants," p. 213.

phloxes (Polemoniaceæ) and nightshades (Solanaceæ). The anisocarpous families culminate in the order Scrophulariaceæ, Compositæ and Caprifoliaceæ. The composite family is conceded by most botanists to be the most highly evolved and successful type of dicotyledonous plants and is represented in the diagram, therefore, as at the top of the system. It is not only the most successful type, but it is essentially a type of comparatively modern evolution.

It may be said in conclusion that many of the families represented in the chart occupy tentative positions. More thorough work must be done on many plants and plant families before we can feel assured of the true relationship of many of our most widely distributed families of dicotyledonous plants. All attempts at representing the affinities in a diagrammatic way are to be welcomed.

THE ARRAN'DA LANGUAGE, CENTRAL AUSTRALIA.

By R. H. MATHEWS, L.S.

(*Read October 5, 1906.*)

We encounter the southern limit of the Arranda language about Oodnadatta, the present terminus of the trans-continental railway from Adelaide towards Port Darwin. The language continues northerly from Oodnadatta to Charlotte Waters and onward to Glen Helen Cattle Station and Alice Springs, in the Macdonnell Ranges. The distance from Oodnadatta to Alice Springs is 347 miles along the public mail-coach road, but as the Arranda language extends some 50 miles farther north, we may say that the length of territory occupied by the people speaking that language, or dialects of it, is 400 miles, by a width of say 200 miles at the widest part—the greatest width being near the northern end in the Macdonnell Ranges and sources of the Finke River.

In 1875, more than thirty years ago, Mr. Christopher Giles, who was then station master at Charlotte Waters telegraph station, reported that the tribes in that neighborhood spoke the Arrinda (my Arranda) language and were divided into four sections, the names of which he stated, together with their intermarrying rules.[1] From information obtained from W. H. Willshire and other men who had resided many years in the district and were well acquainted with the natives, I communicated an article to this Society in 1899 showing a correct table of their intermarrying laws.[2] In 1900 I sent another article to this Society, with a map defining the southern boundary of the Arranda speaking people.[3]

In 1891, Rev. L. Schulze, a missionary at the aboriginal station at Hermannsburg, on the Upper Finke River, reported his discovery that the natives of that district were subdivided into eight sections. Four of these eight have the same names as the four sections men-

[1] "Folklore, manners, etc., of South Australian Aborigines," pp. 82–91.
[2] *Proc. Amer. Philos. Soc.*, XXXVIII., pp. 78–79.
[3] *Ibid.*, XXXIX., pp. 89–93, with map.

tioned by Mr. C. Giles, already referred to, with four new section names added, making eight divisions in all.[1] In 1899 I supplied a complete table showing the rules of marriage and descent among the eight sections of the Arranda.[2] The reader who wishes to study their sociology is invited to peruse the works quoted.

On the present occasion I shall endeavor to give a short account of the grammatical structure of the Arranda language. In 1890, Rev. H. Kempe, another missionary at Hermannsburg, published a grammar and vocabulary of this language,[3] and I propose to make use of some selections from his work, in addition to fuller information collected recently at my request by a capable friend and correspondent who resides in that district. It may be mentioned here that Mr. Kempe failed to observe the double form in the first person of the dual and plural in the pronouns which is now reported by me for the first time.

It may perhaps be as well to repeat that I was appointed by the Government of South Australia, a Land Surveyor in 1883, and a Justice of the Peace in 1884, both of which positions I still hold. By means of these appointments I have had opportunities which would not otherwise have occurred of carrying on my inquiries respecting the customs of the Aborigines in that State.

GRAMMAR OF THE ARRANDA LANGUAGE.

Articles.

There are no words strictly corresponding to the English articles *a* and *the*. The demonstrative adjectives, *this* and *that*, in their various aboriginal forms, supply the place of the definite article.

Nouns.

Number.—There are three numbers—the singular, dual and plural. Atua, a man; atuantatera, a couple of men; atuantirbera, several men. Another form of dual is: wora, a boy; worananga, two boys. The latter form is used only for persons.

[1] "The Aborigines of the Upper and Middle Finke River," *Trans. Roy. Soc. South Australia*, XIV., 223–224.

[2] *Proc. Amer. Philos. Soc.*, XXXVIII., 76.

[3] *Trans. Roy. Soc. South Australia*, XIV., pp. 1–54.

Gender.—There are two ways of indicating gender in nouns—one of which consists of using different words for male and female, and the other by adding some word indicative of sex.

Atua, a man. Aragutya, a woman. Wora, a boy. Kwara, a girl. Katyia, a child of either sex. Among animals, words signifying "male" and "female" respectively are employed, as: Aranga kaluka, a buck kangaroo. Aranga mala, a doe kangaroo. Among some animals there is a name for the male, quite independent of the creature's usual name.

Case.—The principal cases are the nominative, causative, genitive, instrumental, dative and ablative.

Nominative. When the act remains with the subject, the noun is not declined. For example, atua indama, the man sleeps. Katyia lama, the child goes.

Causative. When a transitive verb is used, the noun takes a suffix, *la,* as: Worala gama, the boy eats. Apmala utnuma, the snake bites.

Genitive. This case is formed by adding *ka* to the nominative, as: Kata, father. Kataka wora, father's boy. The genitive case of a large number of nouns is effected by an abbreviated suffix corresponding to the person and number of the pronoun required, as: Katanuka, my father. Katankwanga, thy father. Katakura, his father; and so on through all the persons and numbers. See table of Pronouns.

Instrumental. This takes *lela,* as, ilupa, an axe. Ilupalela, with or by means of the axe.

The accusative is the same as the nominative, thus, Ta Kwatya nyuma. I water drink (I drink water). In some expressions the accusative takes the dative inflection, as: Atuala worana tukala, the man to-the-boy beat, resembling our expression "the man gave (to) the boy a hiding."

The dative terminates in *na.* Ta Katyiana ndama, I to-the-child give.

Ablative. The case ends in *nga.* Era ulbarinya itityinga erbuma, he a boomerang from—mulga makes. Yinga woranga tarama, I laugh for (the sake of) the boy.

Adjectives.

Adjectives follow the nouns which they qualify and are subject to the same declensions for number and case. Comparison is effected by using words signifying, "This is good—that is bad."

Pronouns.

Pronouns take inflexion for number, person and case. There are two forms in the first person of the dual and plural; one in which the person or persons addressed are included with the speaker, and another form in which the persons addressed are exclusive of the speaker. In the following table the first of these forms is marked "inclusive" and the second "exclusive." The "inclusive" form of the pronouns in the Arranda language has never been published by any other author. I was also the first to report the double "we" in the languages in the southeastern districts of South Australia:[1]

There are two district forms of the first person in the singular number, namely, *ta* and *yinga*. Ta is always used when connected with a transitive verb, as, ta tuma, I beat; ta ilkuma, I eat. Yinga is employed when connected with an intransitive verb, as, yinga indama, I sleep. Yinga lama, I go. In the second person singular there are also two forms of the pronuon—*unta* for use with transitive verbs, and *nga* with intransitive verbs. The third personal pronoun, *era*, is regularly declined in all the numbers.

The following is a full table of the *nominative* pronouns. "Transitive" and "intransitive" are respectively noted against the double forms of the first and second pronouns in the singular, to show the verbs with which they are employed. "Inclusive" and "exclusive" are marked against the double forms of the dual and plural.

Singular	1st Person	I, transitive	Ta
		I, intransitive	Yinga
	2d Person	Thou, transitive	Unta
		Thou, intransitive	Nga
	3d Person	He	Era
Dual	1st Person	We, inclusive	Ngilina
		We, exclusive	Ilina
	2d Person	You	Mbala
	3d Person	They	Eratara

[1] "The Bunganditch Language," *Journ. Roy. Soc. N. S. Wales*, XXXVII, 59-74.

Plural	1st Person	We, inclusive	Nganuna
		We, exclusive	Anuna
	2d Person	You	Rankara
	3d Person	They	Etna

The *possessive* pronouns are as under:

Singular	Mine nukara	Thine unkwangara / Thine ngakara	His	ekurara
Dual	Ours, incl. ngilinakara / Ours, excl. ilinakara	Yours mbalakara	Theirs	ekuraratera
Plural	Ours, incl. nganunakara / Ours, excl. anunakara	Yours aragankara	Theirs	etnikara

These pronouns are generally used in the nominative case. For example, the question may be asked, "Whose spear is this?" and some one could answer, "Nukara (mine)." If used in a sentence, the dual and plural forms sometimes have a reflexive or reciprocal meaning, as the verb may determine. There are other forms of the pronouns, meaning "for me," "with me," "to me."

There is also a suffix, *arpa*, by annexing which to the personal pronouns gives them an emphatic meaning, thus:

Ta arpa, contracted to tarpa	Myself
Unta arpa contracted to untarpa	Thyself
Era arpa, contracted to erarpa	Himself

Another emphatic form is obtained by the suffix *atara* in the singular, which is altered to *watara* in the dual and plural. I (in place of anyone else) ta-atara; we, dual, ngilinawatara; we, plural, nganunawatara.

In regard to the double "we" in the dual, there are some variations, according to the relationship existing between the speaker and the person referred to. If a father speaks to his son he says Ngilaka instead of Ngilina, thus: "Ngilika araka larityika, we (dual) kangaroo-for must go. Emphatic forms are, Ngilanta, we (dual) only. Ngunanta or ngunantara, we (plural) only.

Demonstratives. This, rana. These (dual) nanatera. These (plural) nanirbera. This (is mine) nananuka or nanuka. That, tana; those (dl.), tanatera; those (pl.), tanirbera. Other shades of meaning are given by using nakuna and arina for "that." This, lena.

Interrogatives. Who, nguna? Who (did it), ngula? What,

iwuna? In the declension of nguna, the forms of the genitive, dative and ablative are inserted between the root and the termination of the word:

Genitive.	Ngu-*ka*-tera,	of which (dual)?
Dative.	Ngu-*an*-atera,	to which (dual)?
Ablative.	Ngu-*nga*-tera,	from which (dual)?

In the plural we would say, ngu-*ka*-irbera, or contracted to ngukirbera, of which? And so on.

Nguna unta nama, or ngununta nama, who thou art? Ngula nana nilknalinaka, who this stolen has?

Ntakina, how (in what way)? Ntakinya, how (many)? Ntakata, how (large)?

Indefinite pronouns. These are regularly declined. Arbuna, another. Arbunatera, others (dual). Arbunirbera, others (plural). Nintamininta, one by one or, each one.

There are no *relative* pronouns in the Arranda tongue and in this respect it resembles all other Australian languages with which I am acquainted.

Verbs.

The termination of the verb differs in each tense. For example, in the Indicative mood, the word *tuma* means, beats now; *tukala,* means, did beat; *tutyina,* shall beat. Any required number and person in any tense can be shown by using the proper pronoun. In other words, each tense form remains constant through all its numbers and persons. There are, however, modifications of the terminations of the verb in all the moods and tenses to express different shades of meaning, of which I shall give a few examples later on.

Verbs have the usual numbers, singular, dual and plural, each of which can be distinguished by the termination, if connected with a pronoun. When the proper pronoun is used, the dual or plural form of the verb may be omitted. There are three principal moods, the indicative, imperative and conditional. The form of the indicative has already been stated. The imperative is formed by adding *ai* to the stem, as, tu-ai, beat! The conditional mood is formed by the addition of *mara* to the stem, as, tu-mara, should beat. All the moods have a negative as well as a positive form, by infixing or adding *itya* or *gunia* to the positive.

Auxiliary Verbs.—The intransitive verb, ***nama,*** to sit, and having also the sense of our auxiliary, "to be," is employed as a suffix or augmentation in conjugating transitive verbs. The intransitive verb, lama, "to go," is similarly used. Sometimes the whole—sometimes only a part—of these auxiliaries are used as additions to active verbs.

In order to enable the reader to more easily understand the terminations or addenda to the transitive verbs, a short outline of the auxiliary, *nama,* will now be submitted. The present tense is given in full, but in the remaining tenses and moods the first person only of each number is taken.

INDICATIVE MOOD—*Present Tense.*

Singular	1st Person	I am	Yinga	nama
	2d Person	Thou art	Nga	nama
	3d Person	He is	Era	nama
Dual	1st Person	We, incl., are	Ngilina	narama
		We, excl., are	Ilina	narama
	2d Person	You are	Mbala	narama
	3d Person	They are	Eratera	narama
Plural	1st Person	We, incl., are	Nganuna	narirama
		We, excl., are	Anuna	narirama
	2d Person	You are	Rankara	narirama
	3d Person	They are	Etna	narirama

Past Tense.

Singular	1st Person	I have been	Yinga	nakala
Dual	1st Person	We, incl. or excl., have been	As in Present Tense	narakala
Plural	1st Person	We, incl. or excl., have been		narirakala

Future Tense.

Singular	1st Person	I shall be	Yinga	nityina
Dual	1st Person	We, incl. or excl., shall be	As in Present Tense	narityina
Plural	1st Person	We, incl. or excl., shall be		narirityina

IMPERATIVE MOOD.

Be! Sing., nai! Dual, narai! Plural, narirai!
Must be! Sing., nityika! Dual, narityika! Plural, narirityika!

CONDITIONAL MOOD—*Present Tense.*

Singular	1st Person	I should be	Yinga	namara
Dual	1st Person	We, incl. or excl., should be	As in the Pronouns	naramara
Plural	1st Person	We, incl. or excl., should be		nariramara

Future Tense (the Past is wanting).

Singular	1st Person	I should be	Yinga	nityinala
Dual	1st Person	We, incl. or excl., should be	As in the Pronouns	narityinala
Plural	1st Person	We, incl. or excl., should be	As in the Pronouns	narirrityinala

Active Verbs.—The following is a fairly full conjugation of the transitive verb *tuma* or *tula,* to beat:

ACTIVE VOICE. INDICATIVE MOOD—*Present Tense.*

Singular	1st Person	I beat	Ta tuma
Dual	1st Person	We, incl., beat	Ngilina tula narama
		We, excl., beat	Ilina tula narama
Plural	1st Person	We, incl., beat	Nganuna tula narirama
		We, excl., beat	Anuna tula narirama

The negative form is: Singular, tutyikana. Dual, tula narityikana. Plural, tula narirrityikana.

Past Tense.

Singular	1st Person	I have beaten	Ta tukala
Dual	1st Person	We, incl., have beaten	Ngilina tula narakala
		We, excl., have beaten	Ilina tula narakala
Plural	1st Person	We, incl., have beaten	Nganuna tula narirakala
		We, excl., have beaten	Anuna tula narirakala

The negative is formed in the singular by tutyimakana; in the dual by tula narityimakana; and in the plural by tula narirrityimakana or tulta nityimakana.

Future Tense.

Singular	1st Person	I shall beat	Ta	tutyina
Dual	1st Person	We, incl., shall beat	Ngilina	tula narityina
		We, excl., shall beat	Ilina	
Plural	1st Person	We, incl., shall beat	Nganuna	tula narirrityina
		We, excl., shall beat	Anuna	or tulta nityina

The negative form is: Singular, tutyigunia. Dual, tula narityigunia. Plural, tula narirrityigunia or tulta nityigunia.

IMPERATIVE MOOD.

Beat (thou), tuai! Beat (you dual), tula narai! Beat (you plural), tula narirai! Another form, signifying to do the action quickly, is composed by inserting the syllable *-lba* between a duplication of the root, as, tu-lba-tuai, beat quickly. Let me beat, ta tuiai! Let us all, excl., beat, nganuna narireai!

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The negative is: Singular, tutyala! Dual, tula narityala! Plural, tula narirtyala!

Must beat: Singular, tutyika! Dual, tula narityika! Plural, tula narirtyika! or tulta nityika! The negative of these three expressions is formed by adding *gunia.*

CONDITIONAL MOOD—*Present Tense.*

Singular	I should beat	Ta tumara	
Dual	We, incl., should beat	Ngilina	tula naramara
	We, excl., should beat	Ilina	or tulta namara
Plural	We, incl., should beat	Nganuna	tula nariramara
	We, excl., should beat	Anuna	

The negative is formed by substituting *ela* for the final *a,* as, Ta tumarela, I should not beat, and so on.

Future Tense (the Past is wanting).

Singular	I shall perhaps beat	Ta tutyinala	
Dual	We, incl., shall perhaps beat	Ngilina	tula narityinala
	We, excl., shall perhaps beat	Ilina	
Plural	We, incl., shall perhaps beat	Nganuna	tula narirtyinala
	We, excl., shall perhaps beat	Anuna	or tulta nityinala

The negative takes the addition of *gunia.*

PARTICIPLES.

The present tense is formed by adding *manga* to the stem, the past by adding *mala,* the future by *tyinanga.* For example, namanga, while being; namala, after being; nityinanga, shall be being.

PARTICIPLES—*Present Tense.*

Singular	I am beating	Ta tumanga	
Dual	We, incl., are beating	Ngilina	tula naramanga
	We, excl., are beating	Ilina	
Plural	We, incl., are beating	Nganuna	tula nariramanga
	We, excl., are beating	Anuna	or tulta namanga

For the negative singular, tutyikananga. Dual, tula narityikananga. Plural, tula narirtyikananga or tulta nityikananga.

Past Tense.

Singular	I was beating	Ta tumala	
Dual	We, incl., were beating	Ngilina	tula naramala
	We, excl., were beating	Ilina	
Plural	We, incl., shall be beating	Nganuna	tula nariramala
	We, excl., were beating	Anuna	or tulta namala

Negative: Singular, tumalikana. Dual, tula naramalamikana. Plural, tula nariramalamikana.

Future Tense.

Singular	I shall be beating	Ta tutyinanga	
Dual	We, incl., shall be beating	Ngilina	tula narityinanga
	We, excl., shall be beating	Ilina	
Plural	We, incl., shall be beating	Nganuna	tula narirityinanga
	We, excl., shall be beating	Anuna	or tulta nityinanga

Negative: Singular, tutyinagunia. Dual, tula narityinagunia. Plural, tula nariritynagunia.

MIDDLE VOICE—*Reflexive Form.*

The middle voice, in its reflexive form, describes an action which the subject executes directly upon himself. The sign of the reflexive is inserted in the middle of the verb, consisting of the particle *-la* or *-li,* according to the vowel in the adjacent syllable. For example, ta nukara tulama, I beat myself; to nukara tulaka, I have beaten myself; ta nukara tulityina, I shall beat myself. Ta is generally omitted, because nukara conveys the meaning of the first personal pronoun.

INDICATIVE MOOD—*Present Tense.*

Singular	I beat myself	Nukara tulama
Dual	We, excl., beat ourselves	Ilinakara tulala narama
Plural	We, excl., beat ourselves	Anunakara tulala narirama

Negative: Singular, tulityikana. Dual, tulala narityikana. Plural, tulala, nariritykana.

Past Tense.

Singular	I have beaten myself	Nukara tulaka or tulakala
Dual	We, excl., have beaten ourselves	Ilinakara tulala narakala
Plural	We, excl., have beaten ourselves	Anunakara tulala narirakala

Negative: Singular, tulityimakana. Dual, tulala narityimakana. Plural, tulala nariritymakana.

Future Tense.

Singular	I shall beat myself	Nukara tulityina
Dual	We, excl., shall beat ourselves	Ilinakara tulala narityina
Plural	We, excl., shall beat ourselves	Anunakara tulala nariritynina

The negative is formed by adding *gunia,* as, nukara tulityigunia, and so on.

Imperative Mood.

Singular	2d Person	Beat thyself	Unkwangara tulai!
Dual	2d Person	Beat yourselves	Mbalakara tulala narai!
Plural	2d Person	Beat yourselves	Aragankara tulala narirai!

Negative: Singular, tulityala! Dual, tulala narityala! Plural, narirityala!

Singular	I must beat myself	Nukara tulityika
Dual	We, incl., must beat ourselves	Ilinakara tulala narityika
Plural	We, incl., must beat ourselves	Anunakara tulala narirityika

The negative is made by the addition of *gunia.*

CONDITIONAL MOOD—*Present Tense.*

Singular	I should beat myself	Nukara tulamara
Dual	We, excl., should beat ourselves	Ilinakara tulala naramara
Plural	We, excl., should beat ourselves	Anunakara tulala nariramara

The negative is formed by adding *gunia* to the positive.

Future Tense (the Past is wanting).

Singular	I shall beat myself	Nukara tulityinala
Dual	We, excl., shall beat ourselves	Ilinakara tulala narityinala
Plural	We, excl., shall beat ourselves	Anunakara tulala narirityinala

The addition of *-gunia* constitutes the negative.

PARTICIPLES—*Present.*

Singular	I am beating myself	Nukara tulamanga
Dual	We, excl., are beating ourselves	Ilinakara tulala naramanga
Plural	We, excl., are beating ourselves	Anunakara tulala nariramanga

Negative: Singular, tulityikananga. Dual, tulala narityikananga. Plural, tulala narirityikananga.

Past Tense.

Singular	I was beating myself	Nukara tulamala
Dual	We, excl., were beating ourselves	Ilinakara tulala naramala
Plural	We, excl., were beating ourselves	Anunakara tulala nariramala

Negative: Singular, tulamalikana. Dual, tulala naramalamikana. Plural, tulala nariramalamikana.

Future Tense.

Singular	I should beat myself	Nukara tulityinanga
Dual	We, excl., should beat ourselves	Ilinakara tulala narityinanga
Plural	We, excl., should beat ourselves	Anunakara tulala narirityinanga

The negative is expressed by adding *-gunia* or *-itya*.

RECIPROCAL FORM.

This form of the middle voice is a modification of the verb which applies itself to a case where two or more persons reciprocally beat each other, and is consequently limited to the dual and plural numbers. It is known by the termination *rama* for the dual and *rirama* for the plural. Example, ilina turama, we (dual) beat each other; anuna turirama, we (plural) beat each other. A few examples in the third person of the plural will be sufficient to show how the verb is declined in the different moods and tenses.

INDICATIVE MOOD—*Present Tense.*

They, pl., beat each other, Etnikara turirama.
They, pl., beat not each other, Etnikara turirityikana.

Past Tense.

They, pl., have beaten each other, Etnikara turirakala.

The negative form of the word is turirityimakana.

Future Tense.

They, pl., shall beat each other, Etnikara turirityina.

The negative consists of adding *gunia*.

IMPERATIVE MOOD.

Beat each other, aragankara turirai!

They, pl., must beat each other, etnikara turirityika.

CONDITIONAL MOOD—*Present Tense.*

They, pl., should beat each other, Etnikara turiramara.

Future Tense. (Past is wanting.)

They, pl., should beat each other, Etnikara turirityinala.

PARTICIPLES—*Present.*

They, pl., are beating each other, Etnikara turiramanga.

Negative, turirityikananga.

Past Tense.

They, pl., were beating each other, Etnikara turiramala.

Negative, turiramalikana.

Future Tense.

They, pl., should beat each other, Etnikara turirityinanga.

The negative is expressed by *gunia* or *itya*.

There are modifications of the verbal suffixes of the past tense to indicate the immediate past, the recent past, and the remote past. Similar modifications exist for the proximate, or more or less distant future. There are likewise forms of the verb to express repetition or continuance of the act described, and many other complexities, which must be only briefly referred to in the present article. In these respects the Arranda resembles the Kamilaroi, Wiradyuri, Thurrawal and other Australian tongues, the grammars of which have been published by me.[1]

Tutyigunala, to beat by and by.
Tutyilbitnima, to come to beat.
Tutyalbuma, returned to beat.
Tutyikamanityikana, to beat not again.
Tualbuntama, to beat running away.
Tuatalalbuma, to beat on the way home.
Tulinya tulindama, to beat always.
Tulatulauma, to beat seldom.
Tuatna lama, to beat on arrival at another place.

ADVERBS.

Derived adverbs, corresponding with English adverbs ending in *ly*, are formed by adding the particle *la* to adjectives, as, Era ekaltala erguma, he firmly holds.

Adverbs of time: Now, lata. Soon, lilika. Yesterday, tmurka. Day before yesterday, tmurkarbuna. To-morrow, ingunta. Long ago, imanka. By and by, anma. What time? ilangara? Always, kuta.

Of place: Here, nana. There, arina. Near, itinya. Far, longa. Where? ntala? Whither? ntauma? Whence? ntananga. Thither, nauna or arinuna.

[1] *Journ. Anthrop. Inst.*, London, XXXIII, 259–283. *Ibid.*, XXXIV, 284–305. *Journ. Roy. Soc. N. S. Wales*, XXXV, 127–160.

Of number: Once, ninta ranga or ninta ngara. How many times, ntakinyaranga. Twice, tera ranga. Sometimes, urbutya ranga.

Of order: The first, arugula. The last, inkana. Between, mbola.

Of quantity: Much, nyara. Little, kurka. Enough, kala. So, lakina. Like, ngera. More, wota.

Of quality: Slowly, monjala. Badly, kuna. Quickly, parpa. Good or well, mara.

Of affirmation: Certain or true, tutna. Of course, wakuia. Yes, wa or wabala.

Of negation: No or none, itya. None or not, gunia and lira.

Prepositions.

There are two sorts of prepositions, one class comprising separate words, and the other consisting only of small particles annexed to the nouns—both being placed at the end of the word to which they belong. The separate words are as follows:

In front, ulara. Behind, topala. Outside, gatala. Between, mbobula. Other side, ntuara. This side, nunkara. Beside, nkelala. Close by, itinyawara. Through, ntuarintyirka. Upon, katningala. Over, katningalagana. Down, kwanakala. Inside, kwanala.

The prepositions annexed to nouns as suffixes are: Upon, into, una. Example, kwatya-una, abridged to kwatyuna, into the water. Bira-una (biruna), upon the tree. By or with, lela. E. g., atualela, by the man. At, la, as Tyoritya-la, at Alice Springs. With or along with, gata. Without, raba. For, or in exchange, gityala. For (the sake of), kaguia. On (as, on a nail), kieka. From, out of, ibena or ibera.

Conjunctions.

This languages possesses very few conjunctions, most of them being combined with the verb. There is not even a proper word for the copula, and the following are the only examples found: Too, also, tuta or urungara. Yet (nevertheless), etalinya. But, bula. Only, wara. The suffix, *-nta*, also means only. As, than, ngetyina. Then, gurunga.

Interjections.

Hear! aai! I am sorry! apu! Behold! erai! Woe! tyikabai. Indeed, verily, nturbai! Calling attention, tyikai!

NUMERALS.

Ninta, one. Tara, two. Several, urbutya.

ARRANDA VOCABULARY.

The following list of 160 of the most commonly used words in the Arranda language has been written down from the mouths of the native speakers by one of my most valued correspondents in that locality.

Family Terms, etc.

ENGLISH.	ARRANDA.
Man	Atua
Mankind	Rela or erila
Father	Kata or Knaia
Elder brother	Kalya
Younger brother	Tyia or ityia
Boy	Wora
Woman	Aragutya
Mother	Maia
Elder sister	Kwaia
Younger sister	Tyia or ityia
Girl	Kwara
Infant (neuter)	Katyia
Doctor	Ngankara
Wise man	Knarabata
Soul	Guruna and ltana
Wife	Noa-iltya
Good spirits	Tuanyirika
Evil spirit	Erinya
Ghost	Mangabura
Avenging party	Knenka

Parts of the Human Body.

ENGLISH.	ARRANDA.
Head	Kaputa
Eyes	Alkna
Nose	Ala
Tongue	Lenya or alenya
Teeth	Detya
Ears	Ilba
Hand	Iltya or raga
Foot	Inka
Blood	Alua
Penis	Parra
Vagina	Atna
Anus	Gola

Inanimate Nature.

ENGLISH.	ARRANDA.
Sun	Alinga or rerka
Moon	Taia or tninya
Full moon	Ilkapala
Fire	Ura
Water	Kwatya
Camp (general)	Tmara
Smoke	Kwata
Rock	Tēnta
A stone	Pata
Sand	Ulbaia
The ground	Ala or Arila
Pipe-clay	Ikuna
Red ochre	Ulba tataka
Milky way	Ulbaia
Pleiades	Rargua
Orion	Kuralya
Southern cross	Erityinka
Creek or river	Lara
Shadow	Ullincha
Rainbow	Umbulara
Sky	Altyira
Men's camp	Nkanya
Women's camp	Lukara
Meat food	Garra
Vegetable food	Mana
Grass-seed cakes	Egalla
Spinifex gum	Nurbma
Home of souls	Laia

Animals.

ENGLISH.	ARRANDA.
Opossum	Ntāna
Porcupine	Yuta or inalinga
Rock Wallaby	Aroa
Red Kangaroo	Ara
Grey Kangaroo	Aranga
Bat	Ulbulbana
Tame dog	Knulya
Wild dog	Knulya itnora
Emu	Ilia
Eaglehawk	Eritya
Pelican	Kabilyalkuna
Crow	Ngapa
Carpet Snake	Renina
Iguana	Tyunba
Louse	Ita or itya
Native cat	Lukaringa
Bandicoot	Tnunga
Turkey	Itoa
Pheasant	Ngamara
Plover	Bilbilpa
Ring-neck parrot	Erapitya
White cockatoo	Kakalala
Lizard	Ilancha
Scorpion	Natata

Fish	Irbunga
Mosquito	Wunia
Locust	Alknenera
Honey ant	Yeramba
Bull-dog ant	Tyanka
Caterpillar	Weba
Centipede	Inbirka

Implements, etc.

ENGLISH.	ARRANDA.
Stone tomahawk	Lanya or ilapa
Stone knife	Karitya
Stone knife	Irkala
Stone knife	Katua
Shield	Lkuta
Spear	Tyata and ulkuta
Womera	Mera
Boomerang	Ulbarinya
Wooden trough	Tyelya
Yamstick	Tnama
A bag	Taua
Skin bag	Larntua
Brow-band	Chilarra
Arm-bands	Kaltyia
Nose peg	Lalkara
Necklace	Gulitya
Music tube	Albirra
Bullroarer or amulet	Tyurunga

Trees and Plants.

ENGLISH.	ARRANDA.
Grass tree	Lonkura
Desert oak	Irgapa
Red-gum tree	Para or bira
Beefwood	Iltyantya
Bullrushes	Inkua
A flower	Antata

Adjectives.

ENGLISH.	ARRANDA.
Large	Knara
Small	Kurka
Straight	Aratya
Crooked	Inkutinkuta
Good	Mara
Bad	Kunna
Hungry	Ngaiala
Stinking	Intita
Quick	Parpa or intira
Afraid	Ningalkua
Short	Botera
Strong	Ekalta
Plump	Andera
Alone	Egna
Cold	Dana

Thirsty	Ankatala
Sick	Ekna
Tired	Borka
Deep	Ipita

Verbs.

ENGLISH.	ARRANDA.
Stand	Tnama
Sit	Nama
Walk	Lama
Eat	Ilkuma
Drink	Nyuma
Give	Ndama
Talk	Ankama
Beat	Tuma
Throw	Womma
Carry	Ngama
Bite (as dogs)	Utnuma
Bite (in eating)	Kokuma
Weep	Itnima
Go	Lama
Seek	Yaralama
Come	Bityima
Lift up	Tyunama
Dream	Altyirerinya
Laugh	Tarama
See	Airima
Sing	Ilima
Hear or listen	Talakauma

Numerals.

ENGLISH.	ARRANDA.
One	Ninta
Two	Tara
Several or some	Urbutya
Many	Knira and nyara

Stated Meeting October 4, 1907.

President SMITH in the Chair.

The decease was announced of the following members:

John H. Packard, M.D., at Atlantic City on May 21, 1907, æt. 74.

Mrs. Elizabeth Agassiz, at Cambridge, Mass., on June 27, 1907, æt. 85.

Richard Meade Bache, at Philadelphia on July 17, 1907, æt. 77.

Professor Angelo Heilprin, at New York on July 17, 1907, æt. 54.

William Thomson, M.D., at Philadelphia on August 3, 1907, æt. 74.

Charles Stewart Wurts, M.D., at Media, Pa., on August 14, 1907, æt. 78.

Professor John Pomialowsky of St. Petersburg.

The following papers were read:

"New Results in Electrolysis," by LILY G. KOLLOCK and EDGAR F. SMITH (see page 341), which was discussed by Dr. Keller, Mr. Whitfield, Prof. Goodspeed, Prof. Snyder and Dr. Tuttle.

"A Study of Correlations Among Terrestrial Temperatures, as Indicated by Fluctuations in the Sun's Thermal Radiation," by PROF. SIMON NEWCOMB (see *Transactions*, N. S. Vol. XXI, p. 309), which was discussed by Prof. Doolittle, Prof. Snyder and Prof. Haupt.

"Language of the Burdhawal Tribe in Gippsland, Victoria," by R. H. MATTHEWS. (See page 346.)

NEW RESULTS IN ELECTROLYSIS.

By LILY G. KOLLOCK and EDGAR F. SMITH.

(*Read October 4, 1907.*)

(Contribution from the John Harrison Laboratory of Chemistry.)

Since it was observed that anions could readily be estimated by means of the mercury cathode and rotating anode (*Jr. Amer. Chem. Soc.*, **29**, 447), the thought occurred that anions might also be separated by the same means. With this end in view, the following study was undertaken. Potassium ferrocyanide and potassium ferricyanide were the salts used in the work. It was decided to conduct experiments in order to find any difference which might exist in the decomposition pressures. If such conditions did exist, then separations might be effected by this procedure.

The experiments were carried out in the same apparatus and following the directions given in the paper mentioned above. A solution of potassium ferrocyanide, containing in 50 c.c., 0.1316 gram of the salt, under a pressure of 4.5 volts and a current of 0.15 ampere at the beginning, falling to 0.02 ampere at the end, in one hour gave the total $Fe(CN)_6$ present. This was equal to 0.0661 gram. The ferricyanide solution, containing 0.1070 gram of the salt, equivalent to 0.0636 gram of $Fe(CN)_6$, was subjected to the same current, giving the required amount of anion in about the same period of time.

When trying the effect of lower currents, for example 1.5 volt and 0.07–0.02 ampere, upon potassium ferricyanide, it was observed that there was no decomposition of the amalgam in the outer cell. But when phenolphthalein was added to the contents of the inner cell, a strong alkaline reaction was indicated. The silver anode had increased 0.0467 gram after an hour's action of the current, while the amount of potassium present was only 0.0156 gram instead of 0.0253 gram, the equivalent quantity. It was decided to repeat

this work later and to seek for an explanation of its discrepancy, and in the meantime to ascertain the effects of lower currents upon both potassium ferrocyanide and potassium ferricyanide.

A thermopile was used as the source of the current in all the subsequent work. A water rheostat was constructed from a battery jar about twelve inches high by 9″ by 6″ cross section, containing a dilute solution of sodium chloride in which were immersed two lead plates six inches square. The resistance was regulated by raising or lowering the plates in the solution. The voltmeter, graduated to one thirtieth of a volt, and the milliammeter were continually in the circuit.

Potassium ferrocyanide was acted upon by a current of 0.4 volt. This gave a current unappreciable on the milliammeter. It acted for an hour and a quarter. There was no decomposition observed in the outer cell. Titration of the contents of the inner cell with N/10 hydrochloric acid showed the presence of 0.0039 gram of potassium. The anode increased in weight by 0.0052 gram. This is in about equivalent quantities. (The theoretical equivalent of potassium would be 0.00382 gram.) By using a current of 0.13–0.16 volt, there was no evidence of decomposition, either in increase in the weight of the anode or evidence of potassium hydroxide in either cell, with phenolphthalein as indicator. Even 0.02 volt in one hour had not effected any change, but with 0.23 volt, the anode, after an hour's action of the current, had increased 0.0004 gram, and a faint pink color was observed when phenolphthalein was added to the solution in the inner cell. This was dispelled by a fraction of a drop of N/10 hydrochloric acid. With a current of 0.266 volt, the anode after the same period of time had increased 0.0014 gram. When 0.3 volt was employed 0.0022 gram of $Fe(CN)_6$ had separated on the anode and 0.00039 gram of potassium was found in the solution. A current of 0.4 volt showed 0.005 gram of $Fe(CN)_6$ and 0.00107 gram of potassium, while 0.5 volt gave 0.0064 $Fe(CN)_6$ and 0.0041 gram of potassium.

The following table shows the effect of increase in the current:

Current in Volt.	$Fe(CN)_6$ in Gram.	Potassium in Gram.
0.23	0.0004	.....
0.266	0.0014	.....
0.3	0.0022	0.00039
0.4	0.005	0.00107
0.5	0.0064	0.0041
0.66	0.0073	0.0054
0.83	0.0164	0.01209
1.0	0.0174	0.0117

The milliammeter in the last two experiments showed a current of one milliampere at the beginning, which at the end had fallen to 0.0005 ampere.

There appears therefore to be no decomposition of potassium ferrocyanide by currents lower than 0.23 volt.

Experiments were then conducted in order to ascertain the effects of low currents upon potassium ferricyanide. The salt used was recrystallized several times. The solution contained 0.1323 gram of the salt. This was equivalent to 0.0471 gram of potassium and 0.0852 gram of $Fe(CN)_6$. There was no evidence of potassium hydroxide in either cell after the current, having an electromotive force of 0.3 volt and 0.5 milliampere, had acted for half an hour. With 0.66 volt, giving a current of 0.002 ampere at the beginning of the experiment acting for an hour, the anode increased 0.0309 gram in weight and but 0.0039 gram of potassium was found. These experiments confirmed the observations made upon potassium ferricyanide at the beginning of the work. The increase in weight of the anode was out of proportion to the amount of potassium present. Several other experiments with low currents gave similar results. For example, a current of 0.4 volt, after one half hour's action of the current showed only a small amount of potassium but 0.0279 gram of $Fe(CN)_6$. When a current of 0.1 volt was passed, the anode, after an hour's action of the current, increased 0.0223 gram, but there was no evidence of potassium hydroxide in the solution.

An explanation of these results was sought. As the solution changed color, and showed the presence of ferrocyanide on testing with ferric chloride, after electrolysis, it was thought that ferricyanide might first be reduced to ferrocyanide. Four molecules of

ferricyanide would form three molecules of ferrocyanide with the splitting off of one radical, thus:

$$4K_3Fe(CN)_6 = K_{12}Fe_4(CN)_{24}$$
$$3K_4Fe(CN)_6 = K_{12}Fe_3(CN)_{18}$$
$$\overline{Fe(CN)_6}$$

This would therefore give

$$4K_3Fe(CN)_6 : Fe(CN)_6 :: 0.1323 \text{ gram} : 0.0213 \text{ gram}.$$

By constant and careful observation of the voltmeter, it was thought the end of this reaction could be detected.

In the first experiment with this end in view, a current of 0.4 volt and 0.001 ampere was passed through the solution of potassium ferricyanide. There was a constant tendency of the voltage to rise. But by throwing in resistance this was maintained at 0.4 volt, the current falling to 0.0002 ampere. In about thirty minutes the voltage was observed to fall slightly. The current was then interrupted. The anode had increased 0.0217 gram and there was no potassium hydroxide detected in either cell. Subsequent experiments, carrying out the same plan, gave 0.0211, 0.0214, 0.0209, 0.0213 gram increase in weight of the anode. The operations required constant and careful attention, inasmuch as the point at which the change takes place is momentary. The speed of the anode in all cases was about seventy-four revolutions per minute. The time required for the reaction varies slightly with the conditions, as may be observed from the following table:

Current in Ampere.	Volts.	Time in Minutes.	$Fe(CN)_6$ in Gram.
0.001–0.0002	0.4	30	0.0217
0.001–0.0002	0.4	30	0.0211
0.001–0.0002	0.36–0.4	35	0.0214
0.001–0.0002	0.4	35	0.0209
0.002–0.0002	0.4	22	0.0228 (trace of K)
0.002–0.0005	0.4	19	0.0208
0.002–0.0005	0.4	19	0.0213

It therefore seems probable that potassium ferricyanide is at first reduced to ferrocyanide by the current.

That reduction should occur at the anode or in the anode compartment is anomalous. It would perhaps be better to say that a potassium amalgam had formed and in its decomposition hydrogen had caused the reduction of the ferricyanide.

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LANGUAGE OF THE BIRDHAWAL TRIBE, IN GIPPSLAND, VICTORIA.

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(*Read October 4, 1907.*)

In the following contribution I shall endeavor to give an outline of the grammatical structure of the language of the Birdhawal tribe, prepared from notes taken by myself among the survivors of these people. Their hunting grounds were mainly in the extreme eastern corner of the State of Victoria, but they also occupied a small strip of country within the New South Wales frontier. Their boundary may be approximately defined as follows: Commencing on the sea coast, at Cape Conron, and reaching thence along the coast to Mullacoota Inlet, including the following rivers and their tributaries—Bemm, Cann, Thurra, Wingan and Genoa. The Birdhawal territory extended inland from the sea coast to Bonang, Delegete, Craigie, and some other places in that district.

It will be seen that the foregoing description crosses the boundary between New South Wales and Victoria, and takes in the head waters of the Queenboro, Bondi and Nungatta creeks.

The initiation ceremony of the Birdhawal tribe, known as the *Dyerrayal,* has been described by me with considerable fullness in a contribution to the Anthropological Society of Vienna,[1] to which the reader is referred.

All along their western side, the Birdhawal are met by the Kurnai tribe, for a description of the extent of whose territory the reader is referred to my article on "The Victorian Aborigines," which I contributed to the Anthropological Society of Washington, U. S. A., in 1898.[2] For a short grammar and vocabulary of the Kurnai, see my "Aboriginal Languages of Victoria," contributed to the Royal Society of New South Wales in 1902.[3]

[1] Mitteil. d. Anthrop. Gesellsch. in Wien. Band XXXVII, 1907.

[2] *American Anthropologist,* XI., pp. 326–330, with a map showing the distribution of the Native Tribes of Victoria.

[3] *Journ. Roy. Soc. N. S. Wales,* XXXVI., pp. 71–106.

Among the Kurnai, *bra* means mankind, but *kurnai* or *kunnai* distinguishes one of their own men. In the Birdhawal, *mawp* means mankind, whilst *gidyang* signifies a man of their own tribe. Detachments of the Birdhawal community who inhabited the densely timbered tracts, were called *waggarak*. The Birdhawal call their own dialect *mŭk-dhang*, but they distinguish the dialect of the Kurnai as *gūnggala-dhang*. The termination *dhang* in both instances means "mouth," and is symbolical of speech. It may also be mentioned that the Kurnai call their own local dialect *mŭk-dhang*, and that of the Birdhawal *kwai-dhang*. *Mŭk* means good or great, and *kwai* signifies rough; I forget the meaning of *gūnggala*.

If we take the whole of that portion of the State of Victoria lying to the east of the 146th meridian of longitude, and situated between the sea coast and the great dividing range or Australian Alps, we find that the language of the native tribes has the same grammatical structure. This region of Victoria is commonly known as Gippsland, and the language prevailing over the whole area is the Birdhawal, or dialects of the Birdhawal. A glance at a map of Victoria will show that this tract of country embraces the entire sea coast from Cape Howe westerly to Waratah Bay, and extends thence northerly to the great dividing range.

The social organization of the Birdhawal is substantially the same as that of the Woïwurru, Bunwurru, Thagungwurru and other tribes, which has been described by me elsewhere.[1] The social structure of the Birdhawal is also analogous to that of the Thurrawal and kindred tribes situated to the northeast of them in New South Wales, with which I have already dealt in several publications.

Orthography.

The system of orthoëpy adopted is that recommended by the Royal Geographical Society, London, but a few additional rules of spelling have been introduced by me, to meet the requirements of the Australian pronunciation.

Eighteen letters of the English alphabet are sounded, comprising

[1] *Journ. Roy. Soc. N. S. Wales*, XXXVIII., pp. 297–304.

thirteen consonants, namely: *b, d, g, h, k, l, m, n, p, r, t, w, y,* and five vowels: *a, e, i, o, u.*

As far as possible, vowels are unmarked, but in some instances, to prevent ambiguity, the *long* sound of ā, ē, ī, ō and ū are given as here represented. Where the *short* sound of these vowels was otherwise doubtful, they are marked thus: ă, ĕ, ŏ and ŭ.

It is frequently difficult to distinguish between the short sound of *a* and that of *u*. A thick sound of *i* is occasionally met with, which closely resembles the short sound of *u* or *a*.

B has an intermediate pronunciation between its proper sonant sound and the surd sound of *p*. The two letters are practically interchangeable.

G is hard in all cases, and often has the sound of *k*, with which it is generally interchangeable.

W, when it commences a syllable or word, has its ordinary English sound. The sound of *wh* in our word "what" has no equivalent in the native tongue. When *W* occurs in the middle or at the end of a syllable, it is pronounced as in the English words "pawn" and "law" respectively.

Ng at the beginning of a word or syllable has a peculiar nasal sound as in the English word "singer." If we alter the syllabification of this word and write it "si-nger," then the *ng* of "-nger" will represent the aboriginal sound. Or if we take the expression "hang up" and change it into "ha-ngup," and then pronounce it so that the two syllables melt into each other, the *ng* of "-ngup" will also be the sound required. At the end of a syllable, *ng* has the sound of *ng* in king.

The sound of the Spanish ñ frequently occurs. At the beginning of a word or syllable it is given as *ny*, but when terminating a word the Spanish letter ñ is used.

Dh is pronounced nearly as *th* in "that," with a slight sound of *d* preceding it. *Nh* has likewise nearly the sound of *th* in that, with a perceptible initial sound of the *n*.

Th is frequently used at the commencement of a word instead of *dh*, and in such cases an initial *t* sound is substituted for that of the *d*. *Dh* and *th* are generally interchangeable. At the beginning

of a word our English sound of *d* and *t* seldom occurs; it is generally pronounced *dh* or *th*, in the way just explained.

A final *h* is guttural, resembling *ch* in the German word "joch."

Y at the commencement of a word or syllable preserves its habitual sound.

R in general has a whirring sound, at other times it is rolled, and occasionally the English value is assigned to it.

T is interchangeable with *d*, *p* with *b*, and *g* with *k*, in most of the words in which these letters are used.

Ty or *dy* at the commencement of a syllable or word has nearly the sound of the English *j* or Spanish *ch*, thus *-dya* in the word wom-ba-dya, closely resembles *cha* or *ja*.

Some native words terminate with *ty*, as *brety*, the hand. This word can be pronounced exactly by assuming *e* to be added to the final *y*, making it *bret-ye*. Then commence articulating this word, including the *y*, but stopping short without sounding the added *e*. An approximate pronunciation can also be obtained by substituting *ch* for the *y*, making it *bretch*, but omitting the final hissing sound when pronouncing it. In some of the words in the vocabulary I have given the terminal letters *tch* instead of *ty*, as being more easily mastered by lay readers.

In order to express the native sound of some words, I have used the initial letters *wr* and *mr*. The word *wrŭk*, the ground or earth, can be got exactly by making it *wu-rŭk'*, and then pronouncing it as one syllable, with the accent on the last letter. *Wring*, the ear, can be similarly articulated. *Mring*, the eye, can be pronounced by making it *mu-ring'*, and treating it as one syllable. *Mrety* or *mretch*, fire, can be pronounced in the same way.

Articles.

The indefinite article, "*a*," is not represented; but the demonstrative pronouns, in their numerous modifications, supply the place of the difinite article, "*the*." The adverbs "here" and "there," in their several native forms are treated as demonstratives, and are then substitutes for the definite article. Many of them are subject to inflection for person and number, and some have causative suffixes.

Nouns.

Nouns are subject to variation on account of number, gender and case, the inflection being effected by means of postpositions.

Number.—There are three numbers. The singular number denotes one; the dual, two or a pair; the plural number, more than two. Ngurka, a native bear. Ngurkabulang, a couple of bears. Ngurkawamba, several bears.

Gender.—In the human family sex is distinguished by the employment of different words. Mawp, a man. Kurragan, a woman. The gender of animals is distinguished by the words *brangula* and *yuggana,* placed after the name of the animal. Ngurka brangula, a male bear; ngurka yuggana, a female bear.

For a few of the animals, a specific word represents the male, without naming the creature, but in the case of the female, the animal's name must be stated, followed by the distinguishing word, *yuggana.* When the name of any animal is mentioned, without some word signifying the sex, the masculine gender is understood.

Case.—The cases are indicated by inflections—the following being the principal.

Nominative: This case merely names the subject, and is without flection. Gungarang, an opossum; burru, a kangaroo; buran, a spear.

Causative: This represents the subject in action, and is used with a transitive verb. Mawpu gungarang bundan, a man an opossum killed. Kurraganu kalkun mangan, a woman an eel caught.

Genitive: A peculiarity of this case, which I was the first author to report in any Australian language,[1] is that the property and the proprietor each take a suffix. Bagurdyu mawpa, a man's boomerang.

Every object or article over which ownership can be exercised is subject to inflection for person and number; as, bagurdya, my boomerang; bagurngunna, thy boomerang; bagurnga, his boomerang, and so on. The dual and plural contain "inclusive" and "exclusive" forms in the first person.

[1] "The Thoorga Language," *Queensland Geographical Journal* (1901), Vol. XVII., pp. 52–53.

Instrumental: When an instrument is the remote object of the verb, it takes the same suffix as the causative. Mawpu burru bundan buranu, a man a kangaroo killed with a spear.

Accusative: This is the same as the nominative.

There are inflections to denote motion towards or away from any place or thing. Banggea, towards a camp. Bangga, away from a camp.

Adjectives.

Adjectives succeed the nouns they qualify and take the same inflections for number and case. The suffix is often omitted from one of the words, leaving the noun only, or the adjective only, to indicate the declension. Comparison is effected by two positive statements, such as: This is good—that is bad.

Pronouns.

Pronouns are inflected for persion, number and case, but are without gender. The following are examples in the singular number of the nominative and possessive pronouns:

Singular	First person	I	Ngaiu	Mine	Ngaindya
	Second person	Thou	Ngindu	Thine	Ngingunna
	Third person	He	Mindha	His	Ngaianga

In the dual and plural forms of the pronouns there is a double "we" in the first person, marked "inclusive" and "exclusive" respectively.

Dual	First person	We, inclusive	Ngallu
		We, exclusive	Ngallung
	Second person	You	Ngindubul
	Third person	They	Mindhabullong
Plural	First person	We, inclusive	Ngangun
		We, exclusive	Ngangunnang
	Second person	You	Ngindigan
	Third person	They	Mindhagullang

These full forms of the pronouns are not much used, except in answer to a question, or assertively. If some one ask, "Who is going hunting?" a man may answer, Ngaiu, "I am," or Ngallung, "we (dual exclusive) are." If an inquiry be made, "Whose food is this?" some one may reply, pointing to a certain individual, Ngaianga, "his," and so on.

There is but little regularity in the pronouns of the third person in any of the numbers. This is owing to a word more or less different being used to express whether the person meant is near, or at some distance; whether he is going away from, or coming towards, the speaker; whether he is in the front, or in the rear, and so on.

Interrogatives: Who, nganinde? What, nganna? How many, nau-wun?

Demonstratives: Dyinda, this or here. Mindha, that or there. There it is, munda. These demonstratives are declinable for the dual and plural numbers.

There are likewise forms of the pronouns meaning "for me," "from me," "with me," etc., which extend through all the persons and numbers.

VERBS.

Verbs have the usual numbers, persons and moods, as well as an inclusive and exclusive form in the first person of the dual and plural. The following is a short conjugation of the verb "to strike or beat." In most Australian languages the word for striking also means to kill.

INDICATIVE—SINGULAR.

Person.	Present.	Past.	Future.
First person	Bundanetch	Bundadya	Bundinga
Second person	Bundadu	Bundani	Bundinyin
Third person	Bunda	Bundan	Bundin

Although the inflections on the above words sufficiently indicate the person to a native listener, there would be no objection to prefixing the full pronoun, as, Ngaiu bundanetch, Ngindu bundadu, and so on.

The future tenses of the first person of the dual and plural are as under:

Dual	We, inclusive, shall beat	Bundinyil
	We, exclusive, shall beat	Bundinyillung
Plural	We, inclusive, shall beat	Bundingun
	We, exclusive, shall beat	Bundingunnang
Imperative	Beat	Bundin!

REFLECTIVE.

The reflective form of the verb describes an action which the subject executes directly upon himself:

I am beating myself, Bundhattharanetch. All the remaining persons and numbers can be inflected in the same way.

Reciprocal.

There is a form of the verb to express that two or more persons are reciprocally doing the act described:

We, dual, are beating each other, Bundhaiadyillung.

We, plural, are beating each other, Bundhaiagundhiang; and so on for the second and third persons of the dual and plural.

In the past and future tenses of verbs, there are variable terminations to indicate that the act described was done in the immediate, recent, or remote past; or that the act will be performed in the proximate, or more or less distant future. That there was, or shall be, a repetition or continuance of the action, and other modifications of the verbal suffixes, which must be passed over for the present.

Owing to the several inflections of the verb in the past and future tenses just referred to, it is often found convenient, especially when speaking in the dual and plural, to prefix a complete pronoun from the table of pronouns. This leaves the termination of the verb freer for the various suffixes required to convey the different meanings.

There is no special form for the passive voice. The sentence, "a man was kicked by an emu," would be expressed by the paraphrase, "an emu kicked a man."

Adverbs.

Yes, nyung. No, kalligo. To-day, wadya. This evening, wariñ. Yesterday, buna. To-morrow, mimburiñ. By and by, kalla. Some time back, buni-i. Here or this, dyinda. There or that, mindhi. Away yonder, bubburike. Where, ngulman. Dhūnggo, here. I am here, dhūnggomanetch; thou art here, dhūnggomangunna; he is here, dhūnggomana.

Prepositions.

The equivalents of our English prepositions are in some cases separate words, but are also frequently expressed by a verb, as in the Dyirringañ[1] and other languages.

[1] *Journ. Roy. Soc. N. S. Wales* (1902), Vol. XXXVI., p. 166.

Some prepositions can be inflected for person and number. In front of me, dhangullindya. In front of thee, dhangullingunna. In front of him, dhangullana.

Numerals.

One, gu-du-ge or gu-dug. Two, bolang. Several, bunganbandhak.

Birdhawal Vocabulary.

This vocabulary comprises about 285 of the most commonly used words in the Mŭkdhang speech, every item having been noted down by myself from the mouths of the natives. Words of the same kind are grouped under common headings. It is thought that this arrangement will be more convenient for reference and comparison than if tabulated alphabetically.

Family Terms.

Mankind	mawp	Novice	dhūrtungurriñ
A man	gidyang	A woman	kurragan
Old man	muyulung	Wife	bulamirnda
Husband	bulamirnda	Small girl	mullangan
Song-maker	birrarak	Elder sister	mamang
Clever man	badāra	Younger sister	landhakaiang
Guardian of novice	bullu-wrung	Father	babang
Sorcerer	mullamulliñ	Father's father	wēn′-tuin
Small boy	lity	Mother	yuggan
Elder brother	gandhang	Spirit or ghost	birrabang
Younger brother	bāmun	Master	munggan[1]

Parts of the Body.

Head	duduk	Shoulder	kutthak
Forehead	ngirrame	Elbow	dyilmbat
Hair of head	mundyugan	Hand	bretch or brety
Beard	yerrañ	Thigh	thurrin
Eye	mring	Shin	gurrat
Nose	gung	Knee	bun
Throat	dhuluty	Foot	dyinnang
Back of neck	nainindya	Heel	murung
Ear	wring	Sinew of heel	ngurrang
Mouth	dhang	Blood	gruk
Lips	yandang	Fat	kullunga
Teeth	ngurndak	Bone	kurraduk
Breast, female	bāk	Penis	dhun
Navel	nyuranyurin	Scrotum	dhurt
Afterbirth	wandurung	Vulva	dhallung

[1] This term, *munggan*, is applied to any elderly man who is in command for the time being, whether in a family circle, a hunting excursion, a corroboree, a ceremonial gathering, and so on.

Belly	buluñ	Copulation	thabundyan
Heart	yukarang	Semen	barringunna
Tongue	thaliñ	Urine	wirrakin
Liver	bōthunna	Excrement	gunungunna
Arm	nhurung	Venereal	wadyuwadyung

Natural Objects.

Sun	nau-iñ	Darkness	bunban
Moon	yedding	Cold	mŭrbak
Stars	dyuang	Camp	bang
Pleiades	mamangalang	Fire	mretch
Thunder	mirribi	Smoke	dhumbak
Lightning	mallupkan	Flesh (food)	dyāk
Rain	dhau-ak	Day	nau-indyan
Fog	kanggut	Night	bunman
Frost	dhān	Morning	dyibulagambu
Snow	dhulwurung	Evening	warinman
Hail	tuta	Leaves of trees	bulandyŭnga
Water	yarn	Flowers of trees	gōrna
The ground	wrūk	Wild honey	goang'gal
Mud	nyullung	Pathway	bilbukye
Stone	ngurran	Tail of animal	wirruk
Sand	wuddyat	Shadow	mambarung
A hill	bōbal	Grass	nalluk
Mountain	mārru	Songs for dances	gūnyaru
Light	makanau-in		

Mammals.

Native-bear	ngurka	Flying squirrel, small	waikang
Dog	bañ	Ringtail opossum	balgai
Whiteman's dog	wandaial	Kangaroo	burru
Opossum	gungarang	Wallaroo	wandur
Kangaroo-rat	dyimmang	Platypus	gamallang
Native-cat	gunumburung	Porcupine	diddidi
Tiger-cat	gundurung	Water-rat	batbu
Rockwallaby	waiat	Wombat	bunggadhang
Flying squirrel, large	wanda	Bandicoot, long nose	mandu
Flying squirrel, medium	ngat-ngat	Bandicoot, short nose	manyuk

Birds.

Crow	marrangan	Mopoke	gogok
Laughing jackass	gwak	Bronze wing pigeon	gang-gang
Curlew	gwan-gwan	Rosella parrot	duñ
Willy-wagtail	mumanggalang	Common hawk	barakalgal
Swan	gunyak	Plover	birran-dhurran-dhurran
Eagle hawk	mirrung	White cockatoo	brāk
Emu[1]	mai-au-ra	Black cockatoo	nenak
Magpie	guramagang	Black crestless cockatoo	yaiak
Black jay	wēbuk	Lyre bird	bullit-bullit
Black duck	bundyerrung		

[1] Also called gūngwan-gūngwan, from its call.

Fishes and Reptiles.

Mullet	burbiañ	Turtle	ngeth
Eel	galkun	Sleepy lizard	dyirri-dyirritch
Bream	kain	Black lizard	gurgurwurak
Trout	mŭndya	Black snake	gun'umbra
Frog	dhirragaratch	Brown snake	buli-buli
Tree iguana	dhurrang	Tiger snake	kugugun

Invertebrates.

Centipede	maral	Jumper ant	būl-būl
Mosquito	mingalin	Louse	nu-itch
Mussel	bindhagañ	Nit of louse	tūrta
Leech	dhillang	Blow-fly	bŭmba
Bulldog ant	dyŭng	House-fly	gunadada

Trees and Plants.

A squeaking tree	gudabin	Snow gum	warrugang
Ti-tree	dyerad'deru	Sally	bubugu
Stringybark	brungal	Peppermint	dyārang
Wattle	gun'unggur	Messmate	brēak
Ironbark	burrai	Yam	milañ
Cherry tree	murrage	Ferns	war-we
White gum tree	balluk	Mushroom	gillŭn
Ribbon gum	dyua	Reed	yerka
Mountain ash	dhuru		

Weapons, Ornaments, etc.

Tomahawk	kuyan	Headband	dyalbatch
Yam stick	dhatch	Armbands	bibŭrru
Wood spear	bŭrañ	Waist belt	dhuranggal
Reed spear	dhallandyil	Man's apron	burrañ
Spear lever	murriwan	Nose peg	gumburt
Bullroarer	tŭrndun	Woman's apron	dyabañ
Boomerang	bāgur	Net bag	pattyung
Spear shield	birkumba	Doctor's bag	guragang
Waddy shield	mŭrkang	Necklace	takawe
Fighting club	gudyurung	Canoe	guladung
Hunting club	bŭndi	Paddle	gulamban

Adjectives.

Alive	murulman	Slow	waddiakan
Dead	yuragat	Deaf	ngulla-wring
Large	barraude	Blind	ngulla mring
Small	ngullaburi	Strong	ngarrandyil
Tall or long	warkadi	Afraid	dyiran
Short	wombadya	Tired	durandyagat
Good	linya	Cold	mabuklani
Bad	ngallen	Angry	yerkaman
Hungry	miran	Sleepy	burumi
Thirsty	kyan[1]	Glad	yallakani
Red	kugugun	Sorry	yugani
Black	gurumbura	Greedy	nganggalak
White	tarbandrung	Sick	murugani
Jealous	yukañ	Stinking	yugganman
Lame	kŭkadik	Pregnant	wattandyil
Empty	ngadyan	Hollow	ngunguyang
Full	bulitban	Narrow	ngallaburri
Quick	yangadyan		

[1] Pronounced in one syllable.

Verbs.

Eat	dhalane	Breathe	bimbani
Drink	nungblane	Climb	warkbani
Sleep or rest	beandani	Dance	mundadyan
Stand	thetyani	Dive	mirp-gadyan
Sit	nyani	Conceal	nutyu'kan
Talk	dhanggarani	Jump	wambani
Tell	dhŭngani	Step over	wandhani
Walk	yangadyan	Laugh	tyat-yu-a-lad-yan
Run	bingadyan	Scratch	walagaladyan
Chase	murunggani	Forget	wandaguni
Bring	wanggadyan	Stare at	gaiatguni
Take	wanyandab'ila	Send	bindarin
Pick up	manganni	Shine	dakbatch
Throw down	kalak-tyukan	Suck	thālan
Break	kalakatch	Scold	yakbani
Beat or kill	bundani	Swim	banggadyan
Fight	bundaiakan	Search for	ngunladyan
Arise	bingadyan	Spit	dyuk-bladyan
Fall down	bibbagadyan	Smell	bunbuladyan
See	dhakani	Throw	wandyiggane
Hear	wanggani	Roast	gubaladyan
Give	yukananga	Whistle	wingadyan
Sing	watbuladyan	Pretend	gatbaladyan
Weep	nu-adyan	Vomit	kronggadyan
Cook	gubanyan	Sting	bundadyan
Steal	wirrunggani	Call	kandadyan
Ask	watbani		

APPENDIX.

Language of the Kurnai Tribe.

In a monograph published in 1902[1] I submitted an elementary grammar of the Gūnggaladhang, the language spoken by the Kurnai tribe, whose country is situated to the west of and adjoining that of the Birdhawal. In the paper referred to, the examples given in the pronouns and verbs were very much abridged, owing to exigencies of space, and therefore I am now desirous of supplementing what was then published, being the result of further investigations made by myself among the natives. If this additional information be read in conjunction with my memoir of five years ago, and the vocabulary of 300 words which accompanied it, the whole will then exhibit an outline of the grammar of the Gūnggaladhang tongue.

While many of the words of the Gūnggaladhang are nearly the same as those of the Birdhawal, there are a large number which are altogether different. The closest agreement is found among the pronouns and some of the verbs.

[1] *Journ. Roy. Soc. N. S. Wales,* XXXVII, pp. 92–106.

Pronouns.

The following additional examples are now supplied

Dual	First person	We, inclusive,	Ngallu
		We, exclusive,	Ngallang
Plural	First person	We, inclusive,	Ngangan
		We, exclusive,	Ngangannang

There are also forms for the second and third persons in all the numbers. The full forms of the pronouns given in this and the original table are employed chiefly in answering questions. In ordinary conversation the natives use the pronominal suffixes illustrated under the heading of Verbs.

Verbs.

In my former memoir, already quoted, in the second example of the inflection of verbs, at page 95, the *past* tense of the verb *dhakani,* "to see," was inadvertently set down as the *present.* I therefore wish to expunge lines 19 to 21 inclusive on page 95, and substitute the following fuller details of another verb, *dhanggani,* "to speak," in their stead:—

Indicative Mood—Present Tense.

Singular	First person,	I speak,	Dhangganetch
	Second person,	Thou speakest,	Dhanggandu
	Third Person,	He speaks	Dhangga

Past Tense.

Singular	First person,	I spoke	Dhanggandha
	Second person,	Thou spokest	Dhangganinna
	Third Person,	He spoke,	Dhanggañ

Future Tense.

Singular	First person,	I shall speak,	Dhangginga
	Second person,	Thou shalt speak,	Dhangginnin
	Third Person,	He shall speak	Dhanggiñ

Dual First Person	We, inclusive, shall speak,		Dhangginyal
	We, exclusive, shall speak,		Dhangginyallung
Plural First Person	We, inclusive, shall speak,		Dhanggingan
	We, exclusive, shall speak,		Dhanggingannang

Imperative Mood.

Speak! Dhanggin!

REFLEXIVE.

I am speaking to myself,	Dhanggattharanetch

RECIPROCAL.

We, dual, speak to each other,	Dhanggaiadyalliang
We, plural, speak to each other,	Dhanggaiagundhiang

Stated Meeting October 18, 1907.

President SMITH in the Chair.

PROF. HENRY H. DONALDSON read a paper on "The Growth of the Albino Rat as Compared with the Growth of Man," which was discussed by Professors Houston and Conklin.

Stated Meeting November 1, 1907.

President SMITH in the Chair.

PROF. HOUSTON presented a verbal communication deprecating the use of the word "Aerogram" and discussed the use of other terms applied in this connection. He favored the terms "Hertzian or Marconic Telegraphy" and "Marconigram."

Stated Meeting November 15, 1907.

President SMITH in the Chair.

The following papers were read:

"Pastorius," by PROFESSOR M. D. LEARNED, which was discussed by Mr. H. La Barre Jayne.

"The New Theory of Earthquakes and Mountain Formation, as Illustrated by Processes Now at Work in the Depths of the Sea," by PROF. T. J. J. SEE. (See page 369.)

Stated Meeting December 6, 1907.

President SMITH in the Chair.

The decease was announced of Prof. Asaph Hall, at Annapolis, Maryland, on November 23, 1907, æt. 78.

The following papers were read:

"The Treatment of Mental and Moral Retardation," by PROFESSOR LIGHTNER WITMER, which was discussed by Mr. Sachse, Prof. Jastrow, Mr. Goodwin and the President.

"The Languages of Some Tribes of Western Australia," by PROFESSOR R. H. MATTHEWS. (See page 361.)

Stated Meeting December 20, 1907.

President SMITH in the Chair.

The list of donations to the library was laid on the table and thanks were ordered for them.

The decease was announced of The Right Hon. Sir William Thomson, Lord Kelvin of Largs, at Largs, Scotland, on December 17, æt. 83.

PROF. LEWIS M. HAUPT read a paper entitled "The History of Aransas Pass to Date."

The president delivered the "Annual Address."

LANGUAGES OF SOME TRIBES OF WESTERN AUSTRALIA.

By R. H. MATHEWS, L.S.

(*Read December 6, 1907.*)

For the last eight years I have been endeavoring to obtain original information respecting the sociology, language, folklore and customs generally of the aborigines of Western Australia. Early in 1900 I had the matter sufficiently developed to publish the sociology of the tribes on the sources of the Ord, Fitzroy and Margaret rivers in the Kimberley district.[1] Towards the end of the same year I published a map showing the distribution of various tribes possessing different types of sociology throughout nearly the whole of Western Australia.[2]

In 1901 I gave further details of the sociology as well as a vocabulary of one hundred and eighteen words of the language spoken in the Kimberley district.[3] In 1903 I described some interesting rock paintings and carvings, and supplied vocabularies of the languages of the natives at Roebourne and on the Lower Fitzroy river.[4] During 1907 I further illustrated the sociology of the tribes between Albany and Perth, and also that of the Erlistoun tribe.[5] Some of the folklore and customs of the aborigines of Western Australia are now in course of publication by me elsewhere.

In the present monograph I shall briefly deal with the language of some tribes occupying the country approximately from Laverton and Weld Spring eastward to the boundary of South Australia, and extending into the territory of that state for about two hundred miles. The total length of this tract of country may be stated as approximately six hundred and fifty miles and its breadth three hundred miles. Each tribe is treated under a separate heading.

[1] *American Anthropologist*, N. S., pp. 185–187.

[2] *Proc. Amer. Philos. Soc., Phila.*, xxxix, pp. 89, 123–125, 560–575, with map.

[3] *Journ. Roy. Soc. N. S. Wales*, xxxv, pp. 217–222.

[4] *Queensland Geographical Journal*, xix, pp. 45–72.

[5] *Ibid.*, xxii, 1907.

The Loritya Tribe.

This tribe is located on both sides of the boundary between Western Australia and South Australia. Its territory is approximately from Blyth range northerly to Lake Macdonald, including the Tomkinson and Petermann ranges, and reaching into Western Australia a considerable distance. It also extends into South Australia to the Musgrave ranges, Lake Amadeus, and the Ehrenberg ranges.

The grammatical structure of the Loritya language is substantially the same as that of the Perth natives on the Swan river. The nouns, pronouns, verbs and other parts of speech are declined in an analogous manner, and some words of their vocabularies are almost identical. The Loritya grammar is also the same in principle as that of the Arranda language, reported by me in the *Proceedings* (see page 322).

Nouns.

Nouns have number, gender and case.

Number.—There are the singular, dual and plural numbers, which are declined by postfixes; thus, kalaia, an emu; kalaiatara, a pair of emus; kalaiakura, several or many emus.

Gender.—Sex in the human family is distinguished by different words, as: patu, a man; kunka, a woman. For the lower animals, gender is indicated by the addition of the word manti for males and yakura for females. The ordinary native terms for "father" and "mother" are often employed for the same purpose.

Case.—Examples of the nominative, causative, genitive, and instrumental will be given, but there are likewise forms for the dative and ablative. The accusative is generally the same as the nominative.

The nominative indicates anything at rest and is without flexion, as: patu, a man; kunka, a woman; wonna, a yamstick.

Causative: This is used for any action described in a transitive verb, and takes the suffix *nku,* as: paturku waru pungu, a man a rock-wallaby killed.

The instrumental case takes the same suffix as the causative, as: kunkanku inalingi wonnanku pungu, a woman a porcupine with a yamstick killed

Genitive: This case is formed by adding *ku* to the nominative, as: meru partuku, the womera of the man, or a man's womera; wonna kunkaku, a woman's yamstick.

Adjectives.

Adjectives follow the nouns which they qualify and are subject to the same inflexions. Comparison is effected by means of two positive statements, such as: this is good—that is bad. In the declensions of all the cases of nouns, and of their qualifying adjectives, there are modifications in the affixes, depending upon the termination of the word declined. Sometimes the affix of the noun is omitted, sometimes that of the adjective, this matter being regulated by the euphony of the sentence.

Pronouns.

Pronouns are inflected for number, person and case, and contain two forms of the first person in the dual and plural, marked "inclusive" and "exclusive" respectively in the following tables. The nominative pronouns are given in full.

Singular	1st Person	I	Ngaiulu
	2d Person	Thou	Nuntu
	3d Person	He	Paluru
Dual	1st Person	We, inclusive	Nuntungali
		We, exclusive	Ngali
	2d Person	You	Numbali
	3d Person	They	Palumkutara
Plural	1st Person	We, inclusive	Nguntunganana
		We, exclusive	Nganana
	2d Person	You	Ngurangari
	3d Person	They	Tana

The possessive pronouns are as under:

Singular	1st Person	Mine	Ngaiuku
	2d Person	Thine	Nuntuba
	3d Person	His	Palumba
Dual	1st Person	Ours, inclusive	Nuntungalimba
		Ours, exclusive	Ngalimba
	2d Person	Yours	Numbalimba
	3d Person	Theirs	Palumbakutara
Plural	1st Person	Ours, inclusive	Nuntunganamba
		Ours, exclusive	Nganamba
	2d Person	Yours	Ngurangarimba
	3d Person	Theirs	Tanamba

I am not yet in receipt of sufficiently definite information to furnish details of the remaining parts of the Loritya grammar, but the subject will receive further attention in the near future.

The Erlistoun Tribe.

I have not been able to obtain the name of the tribe occupying the country between Menzies and Lake Wells, including Erlistoun, Laverton, Duketon and other places in the Mount Margaret gold field. This tract may be approximately defined as being situated between the 27th and 29th parallels of latitude, intercepted between the 121st and 125th meridians of longitude. I have provisionally adopted the name of the Erlistoun tribe for the aborigines of this region for purposes of reference. The center of the tract of country indicated is approximately four hundred and fifty miles west of the western boundary of South Australia, and about the same distance northeast of Perth, the capital of Western Australia; in other words, about half way between Perth and the Petermann range on the boundary between the two states mentioned.

Any information, therefore, which we can collect and promulgate respecting the language of a tribe so situated must be of the highest value to the ethnologist, being a connecting link between the speech of the natives of Perth and those occupying the region on both sides of the boundary between Western Australia and the neighboring state of South Australia.

I have not yet succeeded in completing a grammar of the language spoken by the natives of the Erlistoun district, but I have been fortunate enough to find a competent and reliable resident of that part of the country, who has supplied me with a vocabulary of one hundred and three words taken down by himself from the lips of old blacks of both sexes, who were well known to him, and upon whom he could depend.

If we compare the vocabularies of the Erlistoun and the Loritya, printed side by side at the end of this monograph, we discover that thirty of the words are the same or practically the same, whilst eight others are very similar. That is to say, more than a third of the Erlistoun words are substantially the same as the corresponding words in the Loritya. I may state that my correspondent was altogether unacquainted with the Loritya dialect, and none of the natives of that tribe were within hundreds of miles of his home at Duketon. There was therefore no possibility of his inadvertently mixing the words of both tribes.

Then, if we compare the Erlistoun vocabulary with the one published by Sir George Grey in 1839 of the Perth language, we find that eleven of the words are the same and that six are closely similar. In 1903 I published a vocabulary of the dialect spoken at Roebourne, taken down by myself from a black fellow belonging to that portion of Western Australia. In comparing that vocabulary with the Erlistoun, six hundred miles distant, we notice that seven of the words are the same and two similar. These agreements in several words of the vocabularies of tribes separated from each other by many hundreds of miles point to a common origin of the speech of the people over a very large geographic area.

Vocabulary.

The following vocabulary contains 127 words of the Loritya language and 103 of the Erlistoun. The words of a similar character are grouped together under separate headings instead of being arranged in alphabetical sequence.

It may be explained here that I sent the same category of English words to both my Loritya and Erlistoun correspondents, which enables us to make a ready comparison. In the case of my Roebourne vocabulary of 1903, referred to in an earlier page, I had a more or less different list of English words for which to obtain equivalents. This remark applies also to Sir George Grey's vocabulary. It is probable that if we were to go to Roebourne or Perth with the list of words contained in the attached vocabulary and interview the natives, the identity or resemblance of many more words could be established than we can see in the present list.

For the Loritya grammar and vocabulary I am indebted to Mr. C. F. T. Strehlow, who has known the tribe for several years. The vocabulary and other particulars of the Erlistoun natives were supplied by Mr. Kenneth Young. Both these men have been in correspondence with me for some time and I can rely upon their information, which was obtained direct from the aborigines.

English.	*Loritya.*	*Erlistoun.*
Mankind	Matu	Wongada
A man	Patu	bundhu
Father	katu	mummali

Elder brother	kuta	kudrolli
Younger brother	malunga	murlunga
Boy	ula	murdilla
Doctor	nangari	
Woman	kunka	nunga
Mother	yako	yaggoli
Elder sister	kangura	ludrolli
Younger sister	malangu	murlungu
Girl	kuyuna	tunguna
Infant	pipiri	diddi
Mother-in-law	wumaru	

The Human Body, Etc.

Head	kata	kuddya
Eyes	kuru	guru
Nose	mula	mula
Tongue	talinya	mullin or midang
Teeth	kadidi	kardidi
Ears	pina	guran
Hand	mara	murra
Elbow	nguku	bōrk
Shoulder		birri-birri
Foot	tyina	dyinna
Knee	mardi	murdi
Blood	ngurka	guyul
Fat	niti	nirdi
Bone	tarka	durga
Penis	kalu	wiba and wilo
Vagina	tyuka	nungna
Anus	kunnatan	buna
Excrement	kunna	guna
Urine	kumbu	

Inanimate Nature.

Sun	tyintu	tyindu
Moon	pira	kulga
Stars	tyil-tyana	mullai
Fire	waru	worro
Charcoal		yirriga
Smoke	buyu	buya
Water	kape	gabbi
Rain	ir-tyingi	tuda
Rainbow	kanturangu	yu-aro
Spring of water		tu-lu-o
Camp		ngura
The ground	manta	burna
Sand	karu	birria
A stone	buli	
Rock	walu	
Hill	puli-urta	
Pipe-clay	ikuna	tunba
Red ochre	ulba mapanu	murda

Animals.

Opossum	waiyuta	waiada
Porcupine	inalingi	mingarri
Rock wallaby	waru	dyi-waigu
Euro	kanala	kulthalla

Red kangaroo	malu	
Bat	ulbulbine	mun-dyar
Dog	papa	wongu
Emu	kalaia	kullaia
Eaglehawk	katuwara	dedo
Pelican	kabilyalku	
Crow	kanka	karn-ga
Common magpie	urari	
Jay magpie	aputan-tyen-tyi	
Pee-wee	kurbaru	kudbaro
Curlew	wilu	
Owl	wiratu	
Iguana	wongapa	kud-bardai
Brown snake	maru-marura	liro
Carpet snake		mullawanna
Mussel	pira-pira	
Mosquito	kewinye	kumminga
Centipede	kanbarka	
Louse	kulu	win-ga

TREES AND PLANTS.

Red gum tree	itara	
White gum tree		yarda
Grass tree	ulunkuru	
Beefwood	il-tyan-tyi	
Desert oak	irgapa	
Cork tree		buruga
Narrow-leaf mulga		guya
Black mulga		win-dyal-ga
Honeysuckle		yurabuddi
Turpentine bush		giddi
Spinifex	untia[1]	bilya and tyan-bi
Bullrushes	unka	
Grass	puta	

IMPLEMENTS, UTENSILS, ETC.

Stone tomahawk	ilipi	yilgun
Stone knife	tula and irkili	gun-dyi
Spear	katyi	kar-dyi
Shield	ku-ti-tyi	tarro
Womera	meru	mirio
Boomerang	kali	birridi and wallanu
Club	kunti	kundi
Yamstick	wonna	yan-dya
Lower millstone	tyu-a	kuro
Upper millstone	miri	
Trough, wooden	kuntili	wiria
Girdle	nanpa	nanbar
Apron	matati	gun-dya
Nose-peg	unati	mu-le-iddi
Bullroarer	wunninge	

ADJECTIVES.

Large	buntu	gunanna
Small	wima	tuguni
Straight	tukururu	tugarraru
Crooked	kalikali	grin-grin

[1] There are two sorts of spinifex, one of which grows on the sandhills, and the other on rocky ground The natives have names for both.

Good	pala	
Bad	kuya	
Hot	aranta	bubbarra
Cold	warri	yalda
Hungry	a-in-ma	
Tired	burka	nuria
Greedy	waiangulkunmi	
Stinking	boka	yuna
Thirsty		tan-dyarra

VERBS.

Stand	ngarange	ngarrago
Sit	ninanye	illago
Walk or go	yenanye	thulgargo
Run	talkalunganye	tinyarn
Eat	ngalkunye	nannago
Drink	tyi-kinyi	bubbago
See	nanganye	dargo
Hear	kulinye	kurilgo
Chop	mutunye	
Bite	patanye	
Talk	wonkanye	wongi
Laugh	inkanye	ēgarri
Beat	bunganye	bungugo
Give	yunganye	
Throw	runkanye	
Carry	katinye	
Pick up	mungaratalkanye	mangugo
Throw away	wonniriyenanye	wonnigo
Steal	mulatanka manyinye	woggalgo

NUMERALS,

One	kuta	Not obtained.
Two	kutara	
Several	mankura	

ADVERBS.

Yes	o-wa	Not obtained.
No	we-ya	

CORRECTION.

In volume XXXVIII of this journal, page 77, table II, then publishing the eight intermarrying sections of the Warramonga tribe at Tennant's Creek, Northern Territory, I regret that some errors crept in during my rearrangement of the section names from one of my previous tables. Since then I have published several correct tables, but it is only necessary to refer the reader to one of them, given in *The American Antiquarian*, Vol. XXVIII, pp. 87 seq., table IV, which supplies full details of the intermarrying laws in force among the Warramonga natives.

R. H. MATHEWS.

OCTOBER, 5, 1907.

THE NEW THEORY OF EARTHQUAKES AND MOUNTAIN FORMATION, AS ILLUSTRATED BY PROCESSES NOW AT WORK IN THE DEPTHS OF THE SEA.

(With Maps I.–III.)

By T. J. J. SEE, A.M., Lt.M., Sc.M. (Missou.), A.M., Ph.D. (Berol.), Professor of Mathematics, U. S. Navy, in Charge of the Naval Observatory, Mare Island, California.

(*Read November 15, 1907.*)

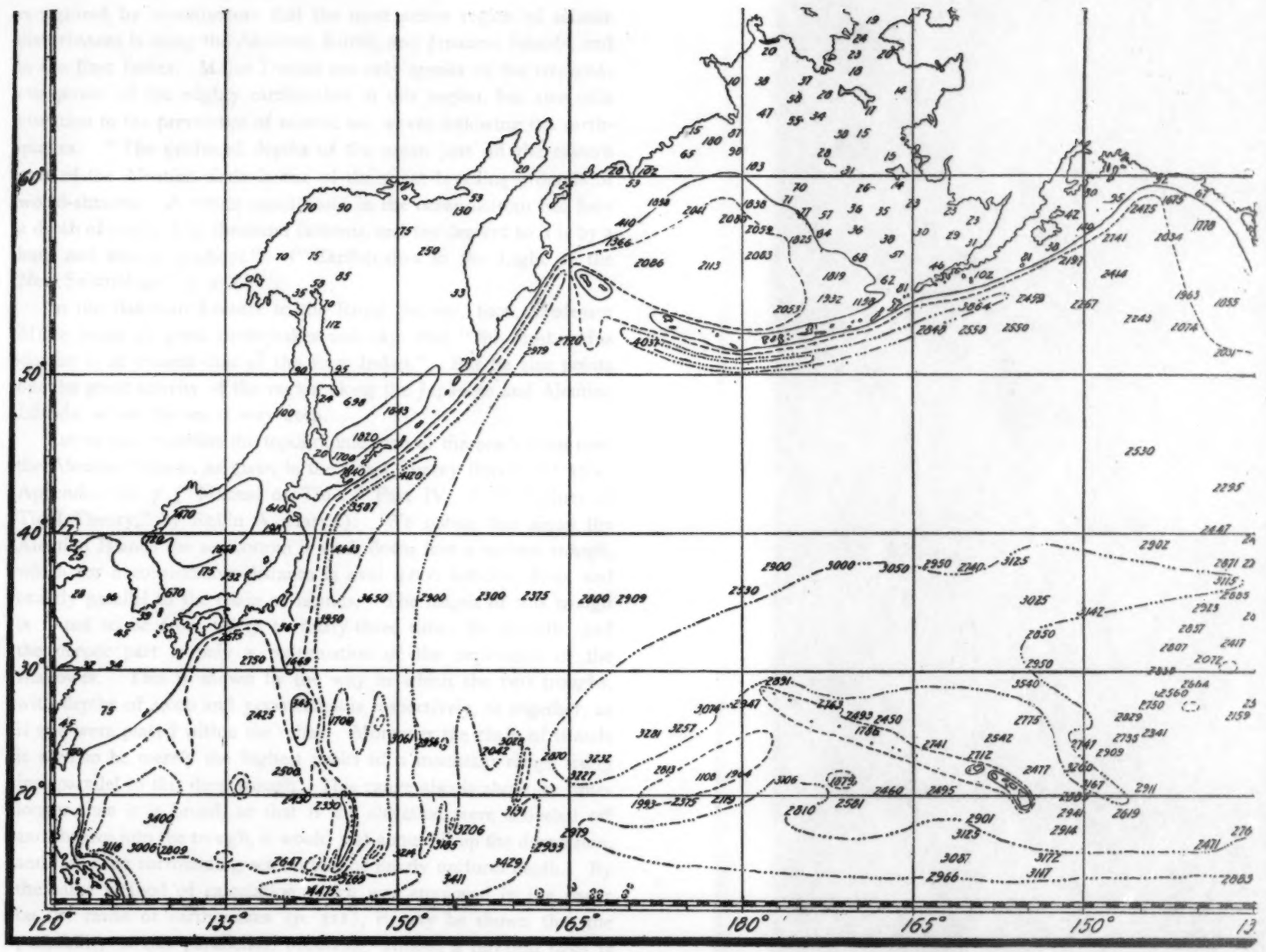
I. On Earthquake Processes Observed in the Depths of the Sea.

§ 1. *General Considerations.*—In two previous papers dealing respectively with the "Cause of Earthquakes" and the "Temperature of the Earth," a new theory has been developed which unites and harmonizes the most varied phenomena connected with the physics of the earth. These papers present the theory in a way which will no doubt seem convincing to the careful reader who has adequate experience in the physical sciences. But even the lay reader is entitled to all the light which may be shed on this difficult subject, and as the departure from previous theories is somewhat radical, it has seemed advisable to record some additional considerations which may be of interest also to the professional student of science.

This course seems the more appropriate in view of the established habits of thought of contemporary investigators, some of whom will naturally welcome any step which will simplify our understanding of physical phenomena. As the subject is extensive and complex and presented under various aspects in the different sciences, a connected view of the laws operating in the development of the earth's crust is by no means easy; for, if it were, the underlying cause no doubt would have been discovered long ago, and great improvements already would have been made in many of the physical sciences which deal with the terrestrial globe.

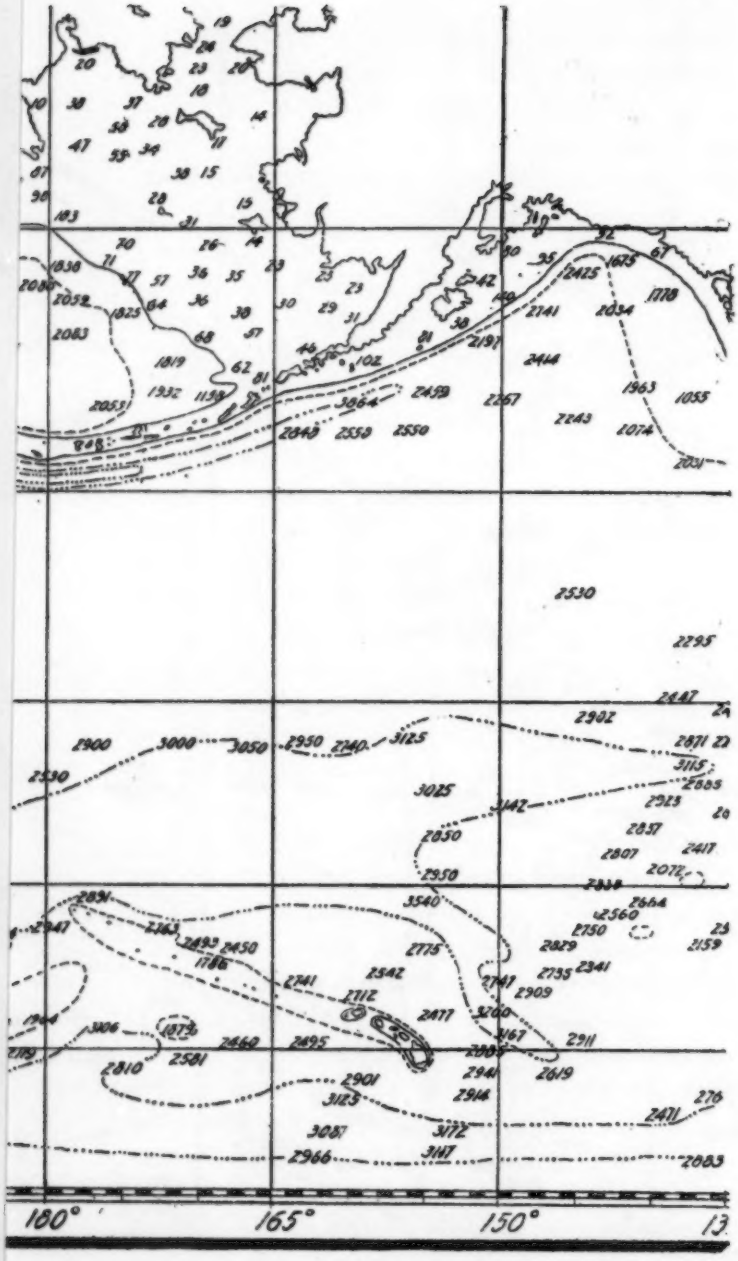
Accordingly if we are able to give concrete and convincing illustrations of the processes now at work in the depths of the sea, they will prove the new theory beyond doubt for certain cases; and then Newton's rule of continuity can be invoked to show that a cause conclusively established in certain cases must be held to be general for all cases whatsoever, where the phenomena are similar. To prove the general physical cause of earthquakes, therefore, we need certain illustrations which admit of but one interpretation, and where there can be no possible doubt about the true nature of the process. If this can be established for a few typical cases we may feel sure that all world-shaking earthquakes and mountain-forming processes depend upon the same physical cause; and that the smaller earthquakes, which are very numerous, depend upon the larger ones and upon the gradual settlement of the crust where for any reason it has become unstable. To unite the small with the large earthquakes, in the hope of finding from the whole body of phenomena, when combined indiscriminately, their general cause, would be to labor in vain; for in the case of the large world-shaking earthquakes there is movement of molten rock beneath the earth's crust, while in the case of small earthquakes the tremors are due to a variety of causes, but more especially to any kind of instability which may give rise to a small movement of the ground. As the earth's crust is thick and the true nature of the underlying movement hidden from our view by the depth at which it occurs, the process involved can not be recognized without excluding from consideration the small earthquakes, and dealing exclusively with those great world-shaking disturbances, in which the effects are so large that the nature of the hidden process can be discovered. The disturbances which show the underlying process most clearly are beneath the oceans, or along the coast of deep seas, where there is expulsion of lava from beneath the sea under the land. We shall now consider some particular cases in which the meaning is unmistakable, and which have only been alluded to in the former papers.

§ 2. *The great earthquakes now occurring in the sea near the Aleutian Islands are developing a high submarine mountain range, of which only a few peaks rise above the water.*—It is generally



COAST SURVEY MAP OF THE NORTH PACIFIC OCEAN, showing the deep trenches in the sea bottom dug out by Earthquakes in uplifting the Aleutian, Kurile and Japanese Islands. In the contour lines 4 points denote a depth of 4000 fathoms, 3 points 3000 fathoms, the continuous dashe 2000 fathoms and the continuous line near shore 100 fathoms.

MAP I.



g out by Earthquakes in uplifting the Aleutian, Kurile and Japanese Islands. In
000 fathoms and the continuous line near shore 100 fathoms.

recognized by investigators that the most active region of seismic disturbances is along the Aleutian, Kurile, and Japanese Islands, and in the East Indies. Major Dutton not only speaks of the tremendous power of the mighty earthquakes in this region, but also calls attention to the prevalence of seismic sea waves following the earthquakes. "The profound depths of the ocean just off the eastern part of the Aleutian chain is one of the great breeding-grounds of world-shakers. A rather small basin in the ocean-bottom has here a depth of nearly four thousand fathoms, and the descent to it is by a long and strong gradient." ("Earthquakes in the Light of the New Seismology," p. 258.)

In the Bakerian Lecture to the Royal Society, 1906, Professor Milne treats of great earthquakes and says that "the most active district is at present that of the East Indies." But he also points out the great activity of the region along the Japanese and Aleutian Islands, where the sea is very deep.

Let us now examine the topographic map of the sea-bottom near the Aleutian Islands, as given in the Coast Survey Report for 1900, Appendix No. 7 ("Manual of Tides," Part IV., A, "Outlines of Tidal Theory," by Rollin A. Harris). We notice that along the Aleutian Islands the sea-bottom is sunk down into a narrow trough, which for a considerable distance is over 4,000 fathoms deep, and exactly parallel to the chain of islands. The length of this trough is found to be from thirty to thirty-three times its breadth; and the deeper part is only a continuation of the depression of the shallower. This is shown by the way in which the two troughs, with depths of 4,000 and 3,000 fathoms respectively, fit together, as if one were placed within the other. Moreover the chain of islands is seen to be merely the highest peaks of a mountain range rising just parallel to this deep trough. This range also is about 33 times longer than it is broad, so that if the elevation were shoveled off and thrown into the trough, it would just about fill up the depression, and leave the surrounding sea bottom of nearly uniform depth. By the same method of calculation which was employed in the paper on the cause of earthquakes (p. 311), it may be shown that the probability of this parallelism occurring without a physical basis is

only $1:(10)^n$, where we may put $n=33$. Thus the chances are only one in a decillion that this geometric parallelism would occur without a common underlying physical cause. The coincidence in volume is even more improbable, so that the agreement in direction and in volume, if depending wholly on accidental coincidence, would have a chance of only $1:(10)^{66}$, or one in a decillion decillions. A decillion decillions is practically an infinite number; and it therefore follows that the coincidence in direction and in volume depends on a true physical cause connecting the elevation of the range with the adjacent depression in the sea bottom.

Moreover, after great earthquakes in this region, new islands are frequently raised from the sea, and several new volcanoes have broken out within historical time. Seismic sea waves of the first class frequently follow, the water first withdrawing from the range of islands towards the trough to the south, and then returning later as a great wave. This shows that the sea bottom to the south sinks after the earthquakes by which the region is afflicted. As the islands, and in fact the whole mass of submarine mountains are uplifted by the disturbance, and the sea bottom afterwards sinks, it is evident that lava is expelled from beneath the trough and pushed under the adjacent range. The bed of the sea then gives down to fill up the partial cavity from which the molten rock has been expelled. It will be noticed, moreover, that the trough lies between the ocean and the mountain range, and hence if the leakage of the ocean were the cause of the expulsion of the lava, the subterranean movement necessarily would be towards the mountain range, in accordance with observation.

From this remarkable series of concurrent phenomena, it follows that the chances are literally infinity to one that the trough and ridge are physically connected. It thus becomes an absolute certainty that the submarine mountain range is formed by the expulsion of lava from beneath the trough, that the whole movement is due to the leakage of the ocean, and that it is going on right now; so that the effects observed within historical time are seen to be but a part of the secular process which has crumpled the earth's crust in this complicated manner.

A study of the map of North America shows that the Alaskan mountains to the north of Cook's Inlet are merely a continuation of the Rocky Mountains of Canada and the United States. The Alaskan mountains form the back bone of the Alaskan peninsula and continue into the sea as the Aleutian Islands. The Aleutian Islands are therefore part of the Rocky Mountains still beneath the ocean to show us how the whole system was formed in the course of immeasurable ages. What is here said about the Alaskan mountains running into the sea applies equally well to various other chains of mountains in different parts of the world.

Thus Mr. Caspar Wistar, formerly a student of Professor E. W. Brown, at Haverford College, now at Temuco, Chile, in sending the writer some valuable observations on the Andes, says: "The coast range begins properly about 25 miles north of Santiago, and there is no trouble in following it until it finally disappears in the ocean in Tierra del Fuego and Cape Horn. Lying between the coast range and the Andes is the central valley of Chile. At the northern end is the highest part, where it is close to 2000 feet above sea level; this gradually grows less as one goes south until finally at Puerta Montt it enters the ocean and can be followed on south below the sea level to Smyth's Channel and the western part of the Straits of Magellan."

In like manner the mountains of the peninsula of Lower California are continued under the sea; and dozens of other cases could be cited. These need not be dwelt upon here, as they are already sufficiently familiar to the reader. The case of the Aleutian Islands has been chosen for detailed study, because the mountain forming process is still actively at work there in a way which shows its real character.

The true process by which mountains are formed near the margin of the sea is thus recognized and placed beyond all doubt. Accordingly it follows that the old theories of mountain formation must be entirely abandoned, as having no valid foundation in nature. For owing to the similarity of the effects we cannot suppose that some mountains are formed by one process and some by another. All mountain ranges were near the sea originally, and essentially parallel to the shore; and since the mountains rear their lofty summits

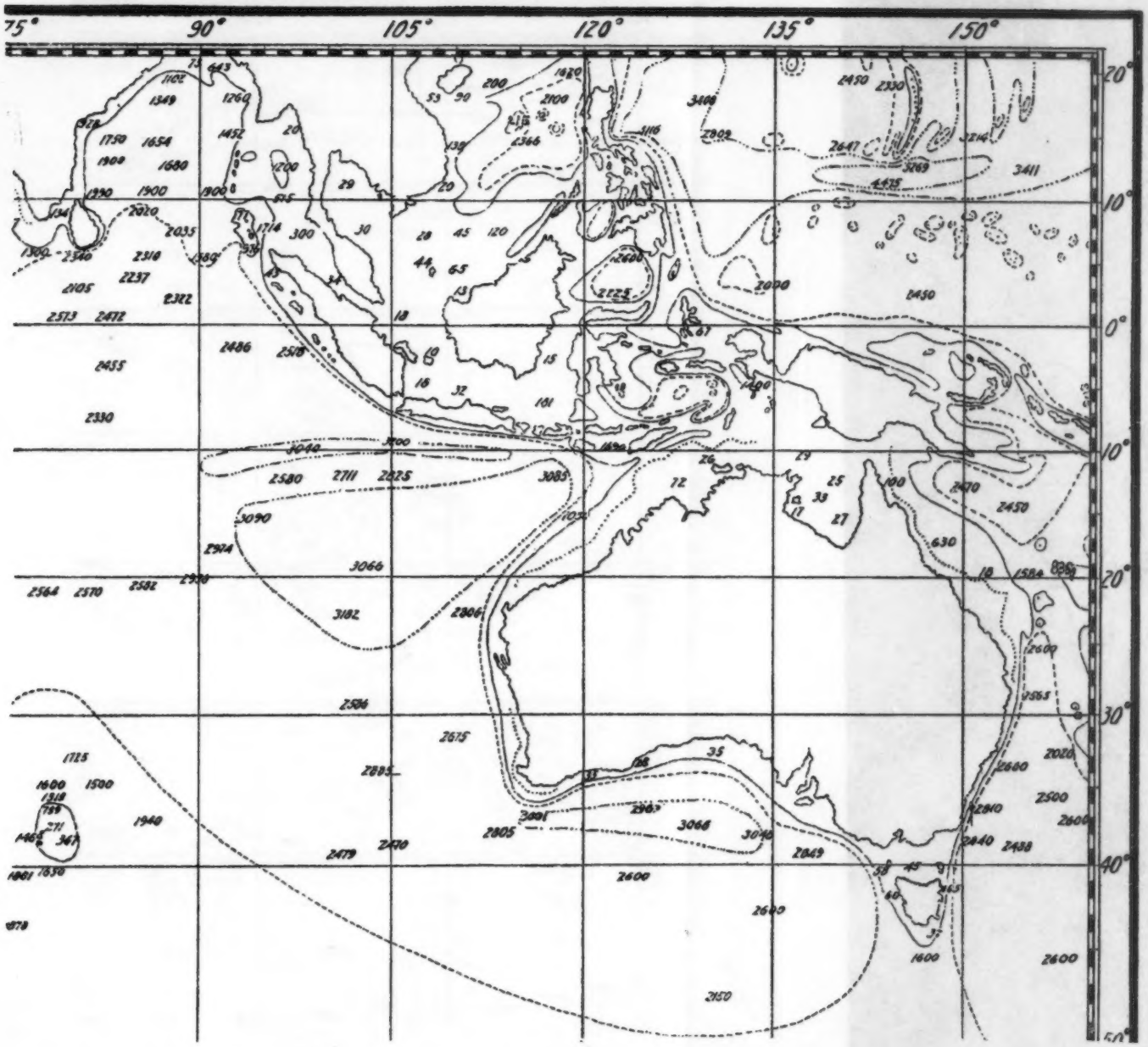
about the sea, as serrated walls around the land, it follows incontestibly that all the mountains of the globe depend on the same cause, which is nothing else than the secular leakage of the ocean bottoms.

Reasoning similar to that here employed could be extended to the deep trenches near the Kurile and Japanese Islands; and by the study of the map of the ocean depths throughout the world one could tell very closely what the state of seismic activity is in any given region. No such digging out of troughs and elevation of adjacent ranges is found to be going on within any continent, and hence it follows that all mountain ranges have been formed by the sea and not at all by the shrinkage of the globe, which obviously is cooling as much in the desert regions as along the sea coasts.

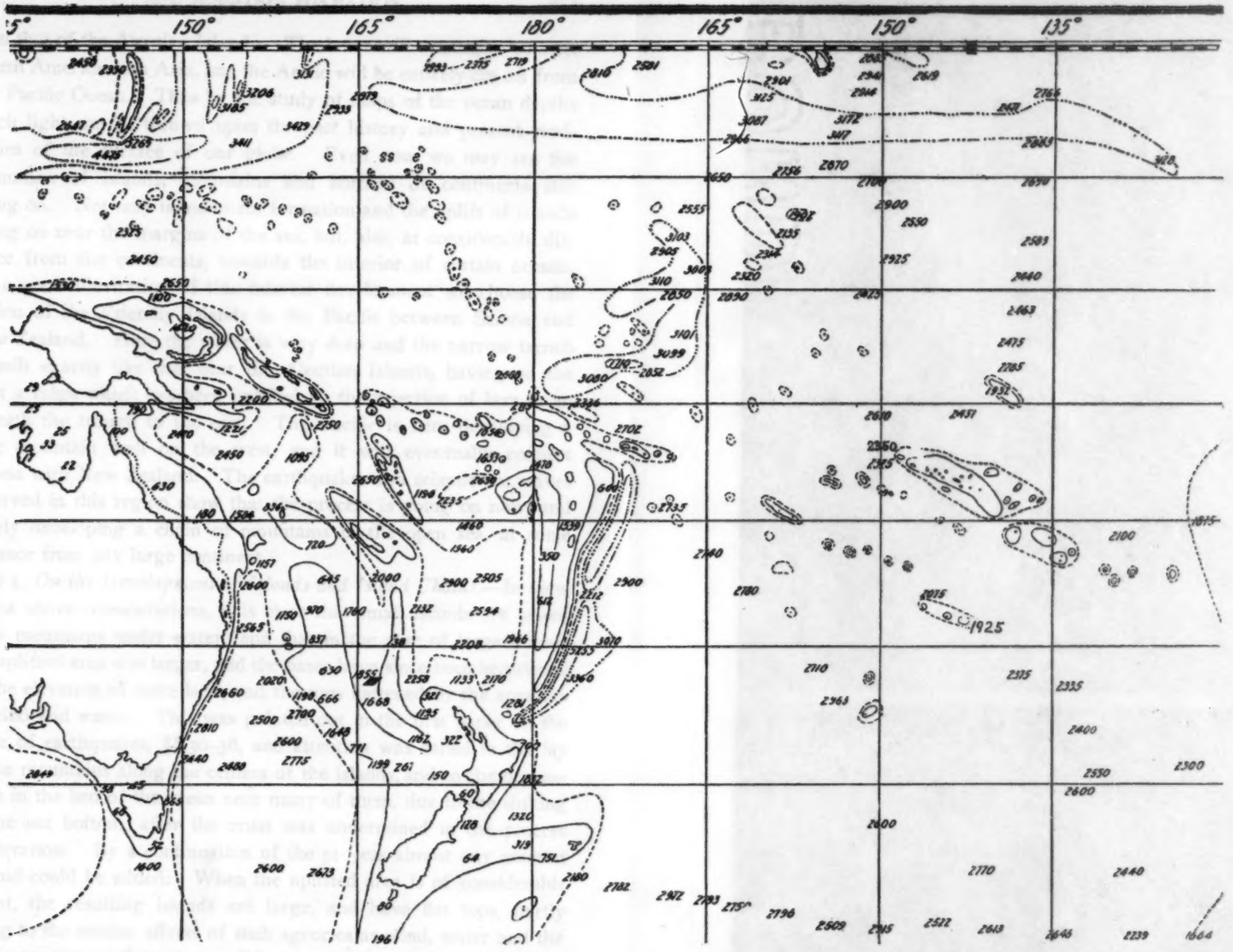
§ 3. *Application of this Theory to Particular Regions of the Ocean Bottom.*—In view of what has been said above regarding the uplifting of ranges in the sea, is it any wonder that volcanoes should break out in the Aleutian Islands? Or, as Major Dutton remarks, that the Russians should connect the earthquakes with the volcanoes of this region? The connection is now established beyond all controversy, and it is shown that the earthquakes are the cause both of the volcanoes and of the mountain formation now going on in the Aleutian Islands.

In Japan the very same cause is at work, and the whole island Empire has been uplifted from the depths of the sea by the injection of lava expelled from beneath the bed of the Tuscarora Deep, which has thus sunk down and developed into the greatest abyss in the world. The true cause of the earthquakes and sea waves by which Japan is afflicted lies in the depth of the ocean to the east of these islands and the resulting leakage and expulsion of lava from beneath it. As the ocean is deepening all the time, this region will always be greatly afflicted by seismic disturbances, and the Japanese people must adapt themselves to the nature of their unstable country, which is still emerging from the depths of the ocean.

It is easy to apply this same reasoning to the East Indies, and hence we see why Java, Sumatra, and other neighboring islands are so afflicted by earthquakes, volcanoes, and seismic sea waves. This region probably is in a more advanced stage of development



COAST SURVEY MAP OF THE REGION OF THE EAST INDIES. In the contour lines 4 points denote a depth of 4000 fathoms, 3 points 3000 fathoms the continuous dashes 2000 fathoms, and the continuous line near shore 100 fathoms.



COAST SURVEY MAP OF THE REGION OF THE FRIENDLY ISLANDS, SOUTHERN PACIFIC OCEAN, showing the deep trenches dug out in the sea bottom between Samoa and New Zealand. Here the Earthquakes are developing a great mountain range on the western side of the Pacific, analogous to the Andes on the East. In the contour lines 4 points denote a depth of 4000 fathoms, 3 points 3000 fathoms, the continuous dashes 2000 fathoms, and the continuous line near shore 100 fathoms.

than that of the Aleutian Islands. The latter will eventually connect North America with Asia, and the Arctic will be entirely cut off from the Pacific Ocean. Thus by the study of maps of the ocean depths much light can be thrown upon the past history and present tendencies of the surface of our globe. Even now we may see the formation of islands, mountains and borders of continents still going on. Not only is mountain formation and the uplift of islands going on near the margins of the sea, but, also, at considerable distance from the continents, towards the interior of certain oceans. As a good illustration of this interior development we choose the region of the Friendly Islands in the Pacific between Samoa and New Zealand. Here the water is very deep and the narrow trench is built exactly like that near the Aleutian Islands, having on the west a ridge which has been uplifted by the injection of lava from beneath the trough to the east. The Pacific is here developing a long mountain wall on the west, and it will eventually connect Samoa with New Zealand. The earthquakes and seismic sea waves observed in this region show that the process is going on now, and slowly developing a chain of mountains in the open sea, at some distance from any large continent.

§ 4. *On the Development of Islands and Island Chains.*—In view of the above considerations, it is clear that small islands are essentially mountains under water; and that in the case of large islands the uplifted area was larger, and the bases have since been broadened by the elevation of more land, and the tops flattened by the agencies of wind and water. This was pointed out in the first paper on the cause of earthquakes, §§ 30–38, and attention was called to the lay of the mountains along the centers of the islands, and to the depressions in the bed of the ocean near many of them, due to the sinking of the sea bottom, after the crust was undermined in the process of elevation. By a continuation of the process almost any amount of land could be added. When the uplifted area is of considerable extent, the resulting islands are large, and have flat tops, partly owing to the secular effects of such agencies as wind, water and the leveling action of the waves. Whenever we see a chain of islands in the sea, we know that they are essentially the peaks of a moun-

tain range elevated above the water. A case such as that offered by the Aleutian Islands proves this beyond all doubt; yet in most cases the process of formation has been slow, and the present state of the sea bottom does not show exactly how the development came about. From the study of those islands near which depressions exist we may in time gather much light on the details of island development, and in this way add to our knowledge of the geology of the sea. While the illustrations already given show the general nature of the process, it is clear that the sea bottom is still too little explored to enable us to treat of all cases intelligently, and we must therefore wait for more light as the surveys of the oceans are gradually extended. It is obvious that exact surveys of the sea bottom are needed not only for the laying of cables, but also for the study of the earth's geological history; and the time may come when exact ocean surveys may be as important for our knowledge of the physics of the earth as geological or geodetic surveys of the land.

§ 5. *On the Nature of the Molten Rock Which Moves Beneath the Earth's Crust.*—In the paper on the Cause of Earthquakes we have pointed out the leaky character of the earth's crust, and shown how steam will naturally form in the hot rocks beneath till the lava becomes so fully saturated by this vapor that it swells and requires more space. The steam is not held to be free, but absorbed in the hot rock, causing it finally to expand till it becomes irresistible; and when the elastic tension of this steam-saturated lava becomes great enough the crust begins to shake and the paroxysm continues till it moves along the nearest fault line. When the underlying molten rock has thus obtained more space, the agitation ceases till the tension again becomes too powerful for the crust to withstand, when another readjustment will take place. Thus the process is repeated at successive somewhat irregular intervals of time. The shaking is due to the enforced movement of the molten rock beneath the crust, and the paroxysm thus developed sometimes shakes down cities and devastates whole countries.

A familiar illustration of this process is seen in the lid of a teakettle when the steam pressure accumulates till it sets the lid quivering; as the steam escapes at the sides the agitation slowly dies down,

and the lid then remains quiescent till the accumulating pressure again requires relief, when the shaking is renewed. Thus the process is periodic, and the period depends on the rapidity with which the steam is developed. In the case of earthquakes, as already remarked, the steam is not free, but absorbed in the molten rock, and when the agitation begins this gives a similar quivering motion to the block of the earth's crust overlying it, and ceases only when readjustment occurs, usually by the neighboring fault slipping in some way to give more space to the swelling lava beneath. The period is not so regular, as in the case of the tea-kettle, because the resistance to be overcome is never the same in two successive earthquakes; nor is an equal amount of relief afforded even when the underlying force is identical, because the crust moves as soon as its resistance is overcome, and it ceases to move when the displacement is sufficient to restore equilibrium. As the resistances to the blocks of the earth's crust are constantly varying, owing to their complicated mutual relations, and the steam also accumulates at various rates and unequally under different parts, the intervals between successive shocks may be approximately, but are never exactly, equal. Settlements after great shocks, and slight stresses, are relieved by small movements, but eventually the tension becomes great enough to demand a displacement that will provide more space beneath the crust, and then the resulting fault movement usually is conspicuous enough to show at the surface of the ground. The crust is about fifteen or twenty miles thick, and molten lava seldom reaches the surface, except when the crust is uplifted and an outlet facilitated by the opening of cracks, as in mountain chains, which may be along the shore, or in the depths of the sea, projecting above the water as islands. Hence not all islands are volcanic; and by no means all mountains become volcanoes; but such outbreaks frequently happen in the neighborhood of deep seas, where the expulsion from beneath the sea is most violent, and the crust is abruptly and sharply upheaved, so as to afford a chance vent for the imprisoned vapor.

§ 6. *The molten rock beneath the oceans probably experiences an enforced creep towards all available avenues of escape, but the movement usually is not rapid enough to prevent the bottom from*

sinking where the undermining due to expulsion is very active.—This may be inferred from the fact that an ocean such as the Pacific is surrounded everywhere by high mountains, and often by table lands of great elevation. All these mountains and plateaus have been raised from the sea, by injections of lava expelled from beneath the bed of the ocean. The fact, however, that in many places, as along the Aleutian, Kurile, Japanese, and East Indian islands, South America, and elsewhere, the expulsion of lava has been so rapid as to dig out trenches near the ranges of mountains thus elevated, leads one to recognize that in some places the expulsion towards the land is more rapid than the creep of lava from under the sea towards the shore, so that the sea bottom sinks down into a trough. This expulsion of lava happens in a good many places, and the phenomena are clear enough to admit of no doubt. Yet it seems certain that some lava creeps under the crust towards all avenues of escape, along the paths of least resistance, and enforced movements occur in submarine earthquakes. Islands are thus raised in the sea, and where the undermining is rapid the adjacent sea bottom sinks down. Sometimes large plateaus form in the ocean, and slowly rise to the surface, so as to form a large flat island, generally of an elongated type. Submarine plateaus of this kind are now to be found in the north and south Atlantic, and elsewhere, and there can be scarcely any doubt that the leakage of the ocean finds relief by the gradual elevation of such submarine masses, as well as along the shores. The effect of this process is to augment the corrugation of the earth's crust in the course of geological time; and eventually the highest mountains in such submarine ridges rise above the water as islands. On October 16, 1907, a very powerful earthquake was felt all over the world, and the seismographic records located it in the Pacific Ocean between Mexico and Hawaii, about 1,000 miles south of San Francisco. This earthquake seems to have been purely submarine, and even more powerful than those which devastated San Francisco and Valparaiso. It is by such submarine movements that the sea bottom is constantly disturbed and corrugated and crumpled in a thousand ways, and some of the elevations are eventually lifted above the water as islands.

§ 7. *The Effects of Pressure upon the Penetration of Water into the Earth's Crust.*—To judge how effective the pressure arising from the depth of the ocean is in driving the water into the crust of the earth, we may observe first that as water is nearly incompressible for moderate pressures, the tendency to penetrate the rocks is everywhere proportional to the depth of the sea. Thus the deeper the water the greater the pressure and penetrating power. Consequently it is chiefly in the deepest water that we should expect to find the maximum effect arising from the secular leakage of the ocean bottoms. In water of any given depth the pressure is theoretically sufficient to throw a free jet to the surface, if the stream could be made to operate in a vacuum. The pressure in a sea one mile deep would thus throw a stream a mile high; in a sea two miles deep, two miles high; and so on. Now some of the ocean depths exceed five miles, the greatest, near Guam, being 5,269 fathoms, almost exactly six miles. Is it therefore any wonder that the deeps east of Japan, near the Aleutian Island, west of South America, near Guam, between Samoa and New Zealand, give rise to enormous leakage of the sea bottom, and consequently many world-shaking earthquakes? A comparatively feeble pressure of water, such as hydraulic engineers use in mining, rapidly cuts away hills and washes out all their gold; in the same way the waters of Niagara, falling through only 160 feet, slowly wear away the solid rock over which they pour.* What then may be expected of a constant water pressure which will throw a jet five miles high? Such is the pressure all over the bed of the Tuscarora Deep, and it continues from year to year, century to century. It is this pressure which forces the water so rapidly into the earth, and gives rise to all the great earthquakes and sea waves with which Japan is afflicted. No stone on earth, however thick its layers, could withstand such a pressure; nay, under it the water would go through the hardest metals, and sink down deeper and deeper into the bowels

* This analogy with the hydraulic effects of streams of water in motion is not perfect, for the water in the deep seas is merely subjected to great pressure, without bodily movement; yet in both cases the water penetrates the stone to a certain depth. In the one case the water keeps on descending into the earth, in the other the surface particles are carried away by the moving stream.

of the earth. Thus subterranean steam would arise beneath the crust and accumulate till relief was afforded by a shaking of the earth, which gave more space for the saturated underlying molten rock. Hence arise the earthquake belts near the deep seas, where easy relief becomes established in the neighboring crust as it is gradually uplifted into a great ridge or mountain chain.

§ 8. *Explanation of the Instability of Steep Slopes near Deep Seas Noticed by Seismologists.*—Montessus de Ballore and Professor Milne both dwell on the instability of steep slopes near deep seas. The meaning of this is now plain; namely, the slopes become steep by the uplifts due to the expulsion of lava from beneath the deep seas, and the seismic instability arises from this expulsion of lava under the land. The converse proposition for shallow seas is obvious enough, and well illustrated almost all over the world. In some places relief goes on after the seas have become shallow, but there can be scarcely any doubt that the movement started when the water was deeper than it is now. *The world as we find it represents the cumulative effects of physical causes working over vast periods of geological time. And our best rule is to study the typical processes where the water is deep, and the undermining and upheaval so plain as to admit of no doubt. In time we may be able to trace out the history of other unstable regions now in shallow water, or even above the sea level.* No one would now expect to see a range of mountains form far inland, and where such ranges now stand the bed of the sea once encroached. In the course of time the details in the development of such ranges will no doubt be fully worked out, but geology is not yet sufficiently advanced to unravel all that is hidden in the crumpling and folding of the earth's crust. The progress of the next two centuries ought to enable us to write a fairly accurate history of the development of the earth. All the details of particular regions now being gathered would be unintelligible unless analyzed by means of correct underlying principles, and as these have only been established very recently, we content ourselves with outlining correct general ideas, and illustrating the true physicial cause by a few cases which are beyond question. More cases can be added when our knowledge of the world is more developed; but it may require the work of several

centuries to bring out this complex development for all the principal regions of the globe.

II. Causes other than the Secular Leakage of the Ocean Bottom.

§ 9. *The presence of mountain forming processes in the sea, and the absence of such disturbances in the interior of continents excludes the consideration of secular cooling as an active cause in the modification of the earth's crust.*—In the paper on the temperature of the earth we have seen that secular cooling is a very slow and gradual process; and, moreover, it would necessarily operate as effectively for inland as along the sea coasts. Consequently if this cause were real, it ought to produce effects inland comparable to those along the edges of the continents; but the mountains are forming in the sea, and those already completed are distributed along the sea coasts; so that no one would think of ranges now being developed in an interior region far from the oceans. The absence of such mountain-forming processes in the interior of the continents therefore excludes secular cooling as an active agency in the modification of the earth's crust. *The effects of secular cooling could in no case exceed the disturbances noticed in the inland regions, and as these are insensible in regions free from water, it follows that secular cooling is not a true physical cause of mountain formation and kindred phenomena. Consequently this cause is not now and never has been active in modifying the crust of our globe.*

§ 10. *The Untenability of the Theory that World-Shaking Earthquakes Arise from the Snapping and Bending of Rocks.*—In view of what has been established in this series of papers, it is difficult to see how any one could again ascribe world-shaking earthquakes to the bending and snapping of rocks under stresses arising from the progress of secular cooling. If this is the cause which is at work, why should the great seismic disturbances occur chiefly in or near the oceans, and especially where the sea is deep, while inland regions remain quiescent? By no possible stretch of the imagination can these movements be traced to the secular cooling

of the terrestrial globe. For, if so, how are we to explain the digging out of ocean trenches and the elevation of the adjacent crust into a mountain range, as often happens in the depths of the sea? If any kind of wrinkling due to secular cooling were at work, it seems certain that the inland regions could not escape the same influence.

The difficulty experienced in accounting for the vibrations of the great earthquake at San Francisco, on the hypothesis that a rock had snapped or slipped, is thus fully sustained. If such a cause had given rise to the earthquake, the vibrations would have been of simpler character, accompanied by less rotatory motion, and the whole disturbance would have been less violent and of much shorter duration. It may be asserted with confidence that no vibrations arising from the snapping of rocks would have been sufficiently powerful or long continued to shake down cities and spread universal devastation over the land. Above all, such effects of secular cooling could not explain a general phenomenon like the uplifting of the mountains as veritable walls about the margins of the sea. Nothing but the expulsion of lava from under the sea would be adequate to account for this upheaval of the crust, and it is hard to see how any thing but the shaking incident to this enforced and prolonged subterranean movement could devastate the land and disturb the whole world. In the expulsion of lava from beneath the sea, the true cause of earthquakes is clearly recognized, and all the most important phenomena connected with the physics of the globe are correctly assigned to the secular leakage of the ocean bottoms, which necessarily is greatest where the sea is deepest. This hypothesis alone is adequate to account for all the phenomena of nature. The unity and harmony and mutual dependence shown to exist among the most diverse phenomena observed at the surface of the earth is the best proof of a common underlying cause, and such a theory will strongly commend itself to the natural philosopher who seeks in the abundance and variety of nature indications of a single fundamental law.

How great is the change in the new point of view may be seen from the following discussion by Professor J. W. Gregory, taken from the "London Sunday at Home," 1906:

"A volcano is a pin-prick in the earth's surface and it serves to relieve the local pressure by permitting the escape of steam and molten rock; but an earthquake is produced in most cases by a sudden fracture of the solid substructure of a large region, and as the great mass of material slips into a new position, the shock causes the crust of the earth to shiver from pole to pole. These dislocations are naturally most frequent in regions where mountain ranges are apparently still being squeezed up—where rocky folds are still being bent into shape, as in the Himalayas, and off the west coast of North and South America, and the North of Japan. Regions of greatest instability of the earth's crust are, in fact, found chiefly along the margins of continents or tablelands which rise suddenly to considerable heights above oceanic or other plains. Comparatively few earthquakes have their origin near to volcanoes, and the general belief that all great earthquakes are due to volcanic eruptions is not supported by evidence derived from observations."

Professor Gregory thus says that earthquakes occur chiefly where mountain formation is in progress, but he is entirely silent as to the cause of mountain formation itself. Unfortunately he blindly accepts the traditional doctrine of the secular cooling and contraction of the globe, which is shown to be devoid of any sound physical basis.

§ 11. *An Estimate of the Relationship between the Expansion and Contraction of the Globe.*—It is well known that at intervals the sea coasts are elevated by the world-shaking earthquakes to which they are subjected. It is difficult to form an estimate of the total area thus uplifted, but for a preliminary estimate we may take it to have an average extent of 200 miles square, which would about correspond to the phenomena witnessed in the greatest earthquakes. There would be 4,924, or roughly 5,000, such areas on the surface of the entire globe. According to Milne's estimate of 60 world-shaking earthquakes per annum, there would be 120,000 in the 2,000 years which have elapsed since the century before the beginning of our era.

Now an examination of great earthquakes shows that about one in four is accompanied by a sensible elevation of the disturbed area. If there are in all 5,000 such areas to raise, and 30,000 disturbances for raising them, it follows that on the average, when all areas are affected alike, each part would be raised 6 times in 2,000 years. An average raise of 2 feet is not extreme, and this gives an expansion of the total surface of the globe amounting

to 12 feet in this period. In the paper on the temperature of the earth, p. 286, we have shown that the shrinkage due to cooling in 10 million years, according to Daniell, would not exceed 612 feet; and, taking this effect to be uniform, the shrinkage in 2,000 years would be only 0.12 of a foot, or exactly 0.01 part of the calculated elevation due to earthquakes. Now in the above calculation of the expansion due to earthquakes, we may have taken the disturbed area too large; but one uplift in four great disturbances does not seem to be an over estimation of the effects of elevation. The sinking of the sea bottom, however, goes on, and less frequently the land along the shore is carried down also; and possibly the elevation is relatively less than we have computed. As this calculated expansion is 100 times the shrinkage, we might reduce the size of the uplifted areas to 100 miles square, and still the expansion would exceed the contraction by 25 times. We could again reduce the areas to 50 miles square and make the uplift over 6 times the contraction. If, however, the uplifts be restricted to the areas covered by the land, the effect would be quadrupled. To make the expansion just equal to the contraction we should have to reduce the amount of the average vertical uplifts from 2 feet to 1 inch, or make the 2-foot uplifts 24 times less frequent, so that only one would occur in 96 great earthquakes.

This seems to be excessively small, and I think it practically certain that the expansion of the globe is from 10 to 100 times more rapid than the contraction, in the evaluation of which we have used Daniell's maximum estimate.

When we contemplate the mountains and plateaus, we see that an expansion of our globe is indicated by its general aspects. For it is in this manner that the mighty mountains have been upraised, and the vast plateaus uplifted, without greatly depressing large areas of the sea bottom. As the earth is almost totally devoid of shrinkage due to secular cooling, the maximum estimate being 1.44 inches in 2,000 years, this most probably indicates a secular expansion of our planet. In any given age the expansion is not equally effective all over the terrestrial spheroid, but the present distance of many mountains and plateaus from the sea shows that

it goes on steadily, and in times gives rise to large effects over considerable belts. It seems therefore practically impossible to avoid the conclusion that our earth is not contracting at all, but on the contrary is actually undergoing a slow secular expansion. In any given geological age the areas uplifted may be confined to particular regions, chiefly along the sea coasts, but in the long run it will include a large part of the earth's surface. In the course of ages more and more land is raised above the sea, which at the same time is contracting its extent and decreasing its total volume by the secular desiccation arising from the gradual absorption of the waters into the rocks of the earth.

§ 12. *Researches Founded on the Hypothesis of the Gravitational Instability of the Terrestrial Spheroid Rest on a False Premise.*— Quite recently several of the most learned mathematicians in England have treated of the uplift of the continents and their secular movements, on the hypothesis that these effects are due to gravitational instability in the progressive shrinkage of our planet. It is scarcely necessary to point out that in order to reach correct conclusions we must start from correct premises, as well as follow an unbroken chain of reasoning. One may readily concede that the learned discussions which have appeared from several eminent investigators are perfect specimens of the logical art, and adorned with flawless mathematics. But if the premises are not well founded in nature, the superstructure built thereupon necessarily falls to the ground. It does not seem to have occurred to these learned investigators to examine critically the underlying premises, for no doubt they assumed the historical doctrine of secular cooling and contraction of the globe as unassailable.

From our study of this question, however, it seems certain that the earth's cooling is infinitely slow, and that no sensible contraction or other movements depend on this cause. The observed movements are always near the sea, which shows that they depend in some way upon the oceans. As the land is frequently upheaved along the sea coast, and all the mountains and plateaus have been thus uplifted, it is impossible for such movements to depend upon the mere settlement of a gravitationally unstable planet. Hence in the present en-

crusted state of the earth we must reject the whole doctrine of secular shrinkage as false and misleading.

As the earth was once of larger volume and smaller density than at present, there may have been a time when it was settling owing to gravitational instability, *but this was long before the surface had become encrusted.* Since the consolidation began the cooling has been excessively slow, and no convective circulation has taken place within; consequently the planet has not since experienced any sensible gravitational instability, except that due to earthquakes arising from the penetration of water vapor, which gives rise to mountain formation and kindred phenomena now witnessed at the surface of the earth. The theory of gravitational instability as applied to the earth therefore is not valid, because it applies to a far earlier stage in our history, before the crust had begun to form. The premise underlying this learned reasoning seems therefore false, and we can only look upon such an ingenious speculation as an interesting example of brilliant abstract reasoning, in no way applicable to the present or recent history of our planet. By no possibility could such theories enable us to explain the distribution of earthquakes, or their prevalence near deep seas, where trenches are being dug out in the sea bottom and mountains uplifted along the borders of these abysses.

What is said here in regard to these several investigations applies also to Professor Love's learned discussion of the gravitational instability of the earth, involving the various orders of spherical harmonics. His beautiful mathematical theory is a monument of ingenuity, correct on the hypothesis, but the latter is lacking in physical basis, and consequently the investigation is chiefly valuable as a piece of abstract reasoning of high order, interesting in dynamics, but not applicable to the development of our actual earth.

§ 13. *Views of the Late Professor James D. Dana on Mountain Formation.*—Among the many eminent geologists who have treated of mountain formation, the late Professor James D. Dana stands preëminent for having come nearest to the correct theory; and although the false hypothesis of the contraction of the earth underlies his views and vitiates them, yet they are sufficiently remarkable

to deserve the attention of the careful reader who seeks to follow the historical development of human thought. It is only by a survey of this kind that one gets an adequate perspective of the theories developed in the different ages. Dana's views are given in his "Manual of Geology," 1863, and the most interesting passages are the following:

(*A*). On page 29, he points out that the continents are all walled in by mountains erected about their borders, and adds:

(*a*) "The continents thus exemplify the law laid down, and not merely as to high borders around a depressed interior—a principle stated by many geographers—but also as to the highest border being on the side of the greatest ocean (first announced in *American Jour. Sci.* (2) XVII, vols. III, IV, 1847, and XXII, 335, 1856). The continents then are all built on one model, and in their structure and origin have a relation to the oceans that is of fundamental importance."

He also observes that the borders of continents are from 500 to 1,000 miles wide, and infers that "a continent can not be less than a thousand miles (twice five hundred) in width," otherwise it would not have the characteristic basin form with mountain barriers about a low interior.

(*b*) On page 731 he discusses the evolution of the earth's great outline and reliefs, and of the successive phases in its progress, summarizing his conclusions as follows:

I. "The continents have mountains along their borders, while the interior is relatively low; and these border mountain chains often consist of two or three ranges elevated at different epochs."

II. "The highest mountain-border faces the largest ocean, and conversely."

III. "The continents have their volcanoes mainly on their borders, the interior being almost wholly without them, although they were largely covered with salt water from the Azoic age to the Tertiary. Also metamorphic rocks later than the Azoic age are most prevalent near the borders."

IV. "Nearly all of the volcanoes of a continent are on the border which faces the largest ocean."

V. "The strata of the continental borders are for the most part plicated on a grand scale, while those of the interior are relatively but little disturbed."

VI. "The successive changes of level on coasts, even from the Azoic age to the Tertiary, have been in general parallel to the borders of mountain chains; as those of the eastern United States, parallel to the Appalachians, and those of the Pacific side, as far as now appears, parallel to the Rocky Mountains."

VIII. "The continents and oceans had their general outline or form defined in earliest time. This has been proved with regard to North America from the position and distribution of the first beds of the Lower Silurian—those of the Potsdam epoch. The facts indicate that the continent of North America had its surface near tide-level, part above and part below it (p. 196), and this will probably be proved to be the conditions in Primordial time of the other continents also. And, if the outlines of the continents were marked out, it follows that the outlines of the oceans were no less so."

The three other conclusions announced by Dana are of less interest, and need not be quoted here.

(*B*). The following deductions (p. 732) regarding the positions of the reliefs are of high interest:

"1. The situation of the great mountain chains, mainly near the borders of the continents, does not indicate whether the elevating pressure acted within the continental or oceanic part of the earth's crust. But the occurrence between the principal range and the seacoast of the larger part of the volcanoes (and, therefore, of the profound and widely-opened fractures) of these borders, of the most extensive metamorphic areas, and of the closest and most numerous plications of the strata, as so well shown in North America, are sufficient evidence that the force acted most strongly from the oceanic direction."

"2. The relation between the extent of the oceans and the height and volcanic action, etc., of their borders proves that the amount of force in action had some relation to the size and depth of the oceanic basin. The Pacific exhibits its greatness in the lofty mountains and volcanoes which begirt it."

"3. In such a movement, elevation in one part supposes necessarily subsidence in another; and, while the continental was the part of the crust which was elevated, the oceanic was the subsiding part."

In connection with the theory that the mountains are formed by the expulsion of lava from beneath the sea, through the operation of world-shaking earthquakes, these early views of Dana are of great interest. But in other respects he was led astray by the doctrine of the secular refrigeration of the globe; for he says that "no other cause presents itself that can comprehend in its action the whole globe and all time." He thus speaks as if the entire globe were shrinking, whereas local changes only are occurring, and these always near the sea. Dana's view that "the pressure of the subsiding oceanic portion has acted against the resisting mass of the continents; and thus the border between them has become elevated, plicated, metamorphosed and embossed with volcanoes," is alike

misleading and unjustifiable. For to produce such an effect the settling of the ocean basin would have to be many miles, and we have shown that no such shrinkage has taken place since the crust was formed; on the contrary there is reason to think that the earth is expanding at a rate of from 10 to 100 times that of the contraction due to secular cooling. Moreover we have no more right to assume that the continent is squeezed by the settling of the ocean, than that the ocean is squeezed by the settling of the continent.

We have, however, recalled these views in order to do justice to the most original of the older American geologists, and also to let the student see where he departs from the true line of thought. Many years ago Rev. O. Fisher showed that shrinkage was wholly inadequate to account for the height of the mountains observed upon the earth, which are hundreds of times higher than the contraction theory will explain. In the paper on the cause of earthquakes it is shown that the contraction theory is also emphatically contradicted by the present distribution of mountains. In the present paper and that "On the Temperature, Secular Cooling and Contraction of the Earth, and on the Theory of Earthquakes held by the Ancients," it appears that at present the earth is not contracting at all; so that we are compelled to abandon the older theories entirely.

As heretofore developed geology has presented the strange anomaly of offering no theories adequate to account for the uplift of mountains and plateaus or the deposits of fossil beds thousands of feet above the sea. This is the more remarkable, since in the days of Humboldt, Lyell, and Darwin, the bodily elevation of the land was an accepted item of belief. But subsequently Lord Kelvin, Sir George Darwin, and other eminent British physicists, showed, from the investigation of tidal and other phenomena, that the earth as a whole behaves as a solid; and under the influence of this line of thought geologists gave up the doctrine of the bodily elevation of the land, and restricted themselves to the collapse of portions of the crust under gravity. The theory of collapse, however, utterly fails to explain mountains and plateaus and islands, as well as shells and other organic remains at great height above the sea level. But it was felt that the argument of the physicists against the bodily

yielding of the earth was unanswerable, and so it is for the globe as a whole; yet this does not disprove the existence of a layer just beneath the crust which in earthquakes behaves as fluid*

In the present researches a theory is developed by which these two views may be reconciled, and it is, I think, clearly proved that in earthquakes there is movement of molten rock beneath the earth's crust. It is this movement of molten rock beneath the crust which produces most of the dislocations, crumpling, folding, and fault phenomena studied in geology. If such a theory is justifiable, it shows us how cautious we must be in drawing final conclusions, and how incomplete all the sciences still are to-day.

§ 14. *Criticisms of the Theory here Adopted.*—Not many criticisms of weight have reached the writer since the publication of the papers on the "Cause of Earthquakes" and the "Temperature of the Earth," but he may here notice two to which some attention may be given.

1. *A geologist thinks that the absence of volcanoes about the South Atlantic is difficult to explain.* This supposed difficulty is much less real than it seems; for some submarine volcanoes have been known in that region, and a good many submarine earthquakes. The sea is shallow near the borders, but a long tableland is rising in the center, and we have no means of knowing how many disturbances occur in this region, which is comparatively seldom visited by ships. Probably the lava finds an avenue of escape under this submarine plateau, and some sea waves occur from time to time, but the region is too far from land to produce great inundations of the shore. As the land is not yet lifted into a sharp ridge, the mountains do not yet appear above the water, and such eruptions as occur beneath the

* Since this was written Professor Wiechert of Göttingen has presented to the International Seismological Association in session at the Hague, Sept. 21–26, 1907, a report of the chief results of his researches on the internal constitution of the earth. The existence of long vibrations in the tremors propagated by earthquakes, with periods of eighteen seconds or more, reveals, he thinks, the presence of a layer of liquid or plastic material at a depth of about thirty kilometers from the surface. (See report of meeting by Professor Harry Fielding Reid in *Science*, Jan. 10, 1908.) Note added Jan. 22, 1908.

sea pass unnoticed. It is not remarkable, therefore, that we find so few volcanoes in this region, and the absence of known volcanoes in no way contradicts the theory. Volcanoes usually break out after mountain ridges are folded sharply upward; this stage may come later in the South Atlantic, where the sea is neither very deep nor the gradient very steep near the shores. Consequently in such a region we should not expect at present many volcanoes or great visible earthquake effects.

2. *Some geologists have believed also that the steam escaping from volcanoes comes from the central magma of the globe.* But if this were true, as we have pointed out in the paper on the "Temperature of the Earth" (p. 288), the volcanic outbreaks ought to occur in the interior of the continents as well as near the oceans. For the vapor ascending from the central magma of the globe could not always be deflected around the immense extent of the continents, and appear only at their edges, and in the depths of the sea. The geographical distribution of volcanoes therefore effectively contradicts any such hypothesis.

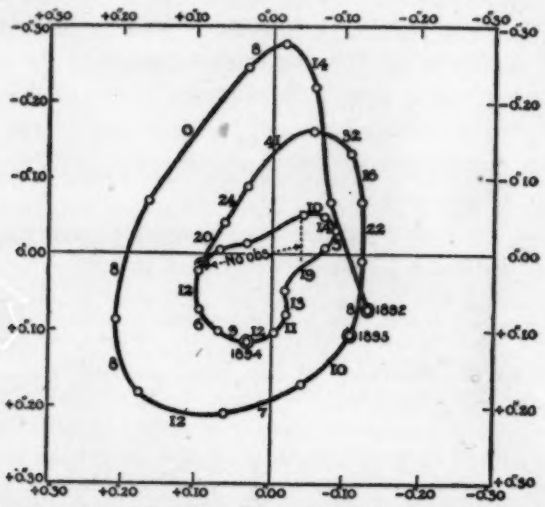
§ 15. *The Criticism based on the Supposed Coincidence of Great Earthquakes with the Sudden Shifting of the Earth's Axis in its Revolution about the Mean Axis of Figure.*—A reviewer of the paper on the "Cause of Earthquakes," in *Nature,* August 1, 1907, after admitting the adequacy of the cause assigned to explain most phenomena finally adds:

> "But his (See's) explanation fails to account for the remarkable connection between the irregular shifting of the earth's axis and the occurrence of the greatest earthquakes. That these irregular movements of the axis are greatest when large earthquakes are most frequent is a certain, but as yet unexplained, fact; it seems to necessitate displacement of matter in the earth on a far larger scale than is indicated by the differential measurements which alone are open to us. Professor See's explanation, though it provides for lateral and vertical displacement of matter, necessitates the elevations and depressions being so closely contiguous as practically to neutralize each other's effects, and, therefore, fails as an explanation of the ultimate cause of earthquakes, while it in no way affects the current acceptance of fracture as their immediate cause."

This criticism is not well founded, and after what has been said above and in the two preceding papers, probably does not require

any elaborate notice; yet we may briefly point out the weakness of the position taken, which seems to be the same as that announced by Professor Milne in his Bakerian Lecture to the Royal Society, 1906, where he says:

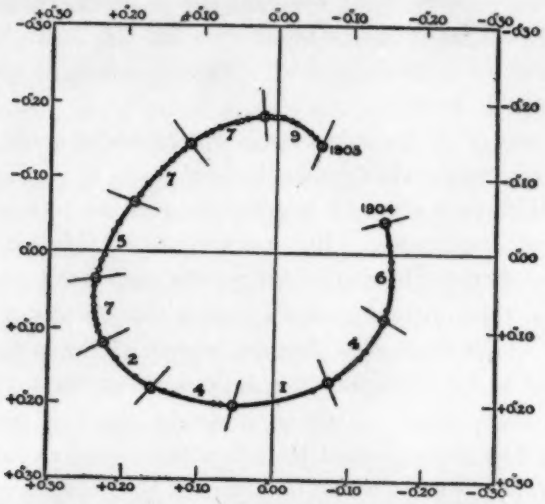
"If we take a chart showing the varying position of our earth's north pole in relation to its mean position, we see that the secular movement of the pole is by no means uniform. Although it may at times follow a path about its mean position which is approximately circular, at other times there are comparatively sharp changes in direction of motion which may even become retrograde. If now on a chart of this description we mark the time positions of very large earthquakes, we find that they cluster around the sharper bends of the pole path." (See the accompanying figures with explanations taken from Professor Milne's paper.)



"FIG. 1. After Th. Albrecht. The path of the North Pole from 1892 to 1894 inclusive. Each year is divided into tenths or periods of 36.5 days. Numerals indicate the number of large earthquakes which occurred in each of these divisions, commencing with the third tenth of 1892."

"In a period of nearly 13 years (1892 to 1904) I find records for at least 750 world-shaking earthquakes, which may be referred to three periods continuous with each other, and each two tenths of a year or 73 days' duration. The first period occurs when the pole movement followed an approximately straight line or curve of large radius, the second equal period when it was undergoing deflection or following a path of short radius, and the third when the movement was similar to that of the first period. The numbers of earthquakes in each of these periods taken in the order named were

211, 307 and 232, that is to say, during the period when the change in direction of motion has been comparatively rapid, the relief of seismic strain has not only been marked, but it has been localized along the junctions of land blocks and land plains where we should expect to find that the effect of general disturbances was at a maximum. It can hardly be assumed that the



"FIG. 2. This is similar to Fig. 1, but refers to the year 1903, during which period the pole displacement was more uniform than that indicated in Fig. 1."

frequency under consideration is directly connected with change in direction of pole movement; but it seems not unlikely that both effects may arise from the same redistribution of surface material by ocean currents and meteorological causes generally."

This reasoning of Milne asserts that the greatest earthquakes occur when the path of the pole bends most rapidly. In reply to this claim we may remark in the first place that it is very doubtful whether a general law of this kind can be fairly deduced from existing observations, because the path of the pole depends on such minute quantities that the curvatures platted may not be real. In the second place, if the assumed law were admitted, the meaning of it would still be open to interpretation, and several of these could no doubt be made without involving a contradiction of known laws.

For the total displacement of the pole from the mean position is nearly always less than 30 feet, and generally less than 15 feet;

these movements correspond to quantities represented in arc by 0″.30 and 0″.15, which are on the very limits of our most accurate astronomical measurements. The apparently sharp turns in the pole path, therefore, may not be real, but merely a delusion arising from some unknown cause. If, however, these sharp turns are real, this fact cannot be certainly established till the polar motion has been repeated many times, and the data now available do not seem sufficient for this purpose.

Moreover, even if the sharp turns are real and it could be proved that the great earthquakes gathered about them, in regard to which there is still much doubt, our interpretation of the results would be open to much uncertainty. For it could not be inferred that large masses of matter are in motion within the earth, and that the displacement of these masses causes a sudden change in the movement of the pole. We have seen that the matter of the earth's interior is kept rigid by pressure, and that no movement deep down in the globe ever takes place. This is shown by the fact that a shock originating deep down would be felt with moderately uniform intensity over a large area, which is disproved by observations showing that all great earthquakes are quite superficial. If no shocks originate at great depth, the only other possible movement would be just beneath the crust; and it is quite impossible that currents could move for great distances just beneath the surface without disturbing the whole intervening region of the globe.

Much as has been done on this difficult subject by the greatest mathematicians, it is not yet known what causes operate to displace the pole from the mean axis of figure, and maintain the displacement in spite of friction and viscosity; but recurring seasonal effects, together with the imperfect rigidity of the earth, have been generally accepted as the chief causes. Is it not, therefore, probable that whatever displaces the pole and thus maintains its revolution about the mean pole, according to the Eulerian Theory as modified by viscosity and imperfect rigidity, may suffer variations through combinations of storms, and other atmospheric and tidal agencies? And that these combinations of varying stresses operate to bring on earthquakes where instability of the crust already exists, from the accumulation of subterranean steam pressure?

These combinations of circumstances are not the dynamical *cause* of the earthquakes, but only the *occasion* for outbreaks when instability is already developed. It might thus be that earthquakes would break out when the polar motion is changing most rapidly, *but the earthquakes do not cause the change; rather they are occasioned by that which makes the change.* Milne's view above quoted does not seem to differ much from this, for he says that "both effects may arise from the same redistribution of surface material by ocean currents and meteorological causes generally," though he overlooks the leakage of the oceans as the cumulative dynamical cause of instability.

On these grounds probably very few will agree with Professor Milne, if he is the reviewer quoted in *Nature,* that the present explanation fails. The facts which he assumes are not proved, and even if they were, the interpretation should be exactly the reverse of that which he has given in *Nature.* Consequently we may dismiss this whole criticism as not well taken. Nothing is more certain than that movements of large masses within the earth adequate to displace the polar motion do not take place. A supposed effect of this kind is contradicted by all that we know of the rigidity and solidity of the earth under pressure of its own mass, which would prevent deep movements, and by the well-established fact that all earthquakes are shallow and the shock limited to one locality. Movements in the sea and in the atmosphere, however, might conspire to displace the pole and vary its rate of movement about the mean position, and the stresses thereby exerted upon the globe might occasion seismic outbreaks where the steam pressure had already approached the limits of stability. If the facts assumed by Professor Milne, are confirmed by time and experience, it is in this way that they must be explained; the outbreak of earthquakes being *occasioned,* but not *caused,* by the surface movements of water and air which displace the pole from its mean position and vary its rate of movement in different parts of the path, and thereby also the stresses exerted upon the different parts of the already unstable revolving globe.

§ 16. *On an Explanation of the Squeezing up of the Continents by the Settlement of the Ocean Basins given in Some Works on*

Geology.—In the work on "Geology" by Chamberlin and Salisbury, Vol. II., p. 129, we find the following curious figure and explanation of the elevation of the continents:

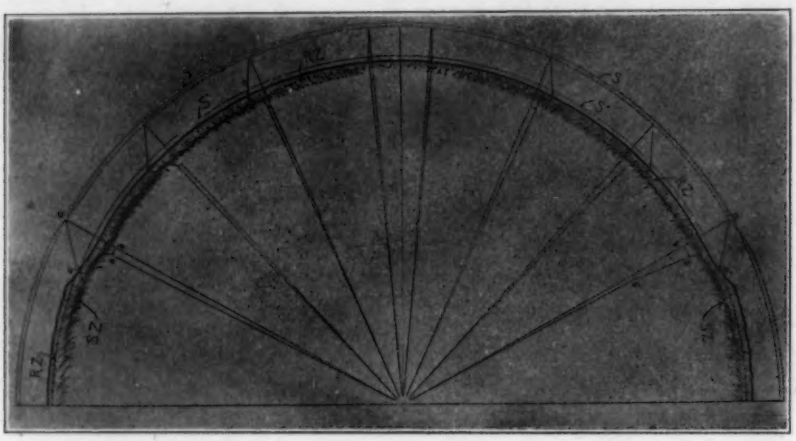


FIG. 3. Illustration of general deformative movement, from Chamberlin and Salisbury's "Geology," Vol. II., p. 129.

"FIG. 32 *C*. Diagram illustrating the supposed elements of a general deformative movement. *SS* represents the outline of the sphere at the ocean level before deformation. The dotted line represents the corresponding surface of the lithosphere, the ocean basin occupying the center and the continents the flanks. *S'S'* represents the outline of the sphere at the ocean level after deformation, the heavy line representing the outer surface of the deformed lithosphere, and the space between *SS* and *S'S'* representing (much exaggerated relatively) the vertical shrinkage which is the great feature of the movement but is only made apparent through its deforming effects. That part of the outer shell which is beneath the ocean is supposed to descend without much compression, while the necessary folding is concentrated on the borders of the continent. The central portion beneath the ocean is represented as descending directly toward the center. The portions on each side preserve their length by thrusting laterally and hence descend along paths represented by the arrow-headed lines, of which those at the border of the ocean, *a*, *a'*, are the most oblique and represent the greatest thrust. On the borders of the continent the crust is folded to the extent of this lateral thrust. This of course only holds true when the thrust is limited to a single oceanic basin. The lateral thrust is chiefly felt in the outer shell or rigid zone, *RZ*, which embraces the heavy line and the dotted zone below. Beneath this lies the shear zone, *SZ*, whose foliated structure is represented as not unlike that of the 'drag' belt of a fault plane. The igneous sheets, batholiths, etc., which are supposed to especially affect this zone are not represented. The great

sector beneath the ocean is represented as having crowded slightly upon the sectors beneath the continents on either hand, this crowding being represented by the short arrows *b*, *b'*. By comparing *bb'* with *aa'* the reason for the shear zone will be made apparent. On the right-hand side the outer part of the sub-oceanic sector is represented as crowding upon the continental sector an exceptional amount, as represented by the deflection of the line *b'b''*. This gives rise to the plateau at the right. The proportions of most of the significant parts are necessarily exaggerated relatively."

Let us now analyse this explanation a little more closely. These authors remark that "that part of the outer shell which is beneath the ocean is supposed to descend without much compression, while the necessary folding is concentrated on the borders of the continent." Is not this a purely gratuitous assumption, simply begging the question, and wholly unjustifiable? Why should the oceans descend without compression, while the continents are squeezed up at their edges? Obviously one has as much right to assume that the oceans are compressed by the sinking of the continents, as that the continents are compressed by the sinking of the oceans. Again, they say that "the portions on each side preserve their length by thrusting laterally and hence descend along paths represented by the arrow-headed lines, etc." But does not the assumption that "the portions preserve their length" imply that the ocean segment has not shrunk at all in respect to surface area, while the continent has been squeezed up at the edge to let it go down?

What right have we to assume a similar shrinkage in the radius of these sectors, and admit a shrinkage in one surface area (the continental) but deny it in another (the oceanic), which is much the larger of the two?

Could one imagine a more improbable effect of secular cooling?

Moreover the above figure corresponds to a shrinkage of about one tenth of the radius, or 400 miles. In view of the fact which has been shown in the paper on the "Temperature of the Earth" that our globe is not shrinking at all, it is unnecessary to make further comment on this unauthorized procedure.

But we may remark that in this "Geology," Vol. II., p. 131, we find a direct contradiction of the above explanation. It runs as follows:

"The continents now rise about 3 miles above the average ocean bottom, and much more than that in certain portions. Since the volume of the ocean has probably not greatly changed during known geological time and since the continents appear to have risen above surface, about as now, in the earliest known geological ages, it is assumed that similar differences of relief have prevailed at the various known deformative periods. We have seen that the gravitative pressure at 3 miles' depth is nearly or quite as great as the shearing-resistance at that depth. If a shearing-zone at depths of 3 to 5 miles had already been developed during the primary deformation, this would facilitate a reversed movement along the same shear-planes. It is therefore conceived that the continental platforms, by pressing upon their bases to the extent of 16,000 to 30,000 pounds to the square inch, would, though opposed by perhaps 5,000 pounds per square inch pressure from the oceans, gradually creep laterally under their own gravity, in a slow glacier-like way. This supposed lateral creep should be attended by crevassing, fissuring, and normal faulting; in other words, *by the prevalent tensional phenomena which the continents present.* It should be much more marked in the plateau regions than elsewhere, because of their superior elevation, and it is there that normal faulting is most pronounced."

Thus in one place we are assured that the continents have been squeezed up, in another that they are creeping down in a slow glacier-like way. If they are creeping down how were the mountains elevated? And why should these uplifts appear at the borders of the continents? Perhaps it will be answered that these two movements are going on together. But does not the first principle of the new theory tell us that neither of these supposed movements has any reality, and that the mountains and plateaus are elevated by the expulsion of lava from beneath the sea, the shells of which are thus carried to the greatest height in the gradual uplift of the land?

§ 17. *On the Folding and Distortion of the Strata seen at the Earth's Surface.*—In many works on geology the crumpling and folding of the strata are attributed to "a gentle warping of the soil." No doubt where mere settlement of the ground is in progress, owing to undermining, there is some warping of the soil; but this implies that the strata have already been uplifted and undermined, so as to become unstable. Such uplifting is the work of earthquakes, during past geological ages, though the settlement and warping may be due to the gradual undermining effects of water or other agency which produces instability. All movements of this kind are of small importance compared to the greater and more violent

derangements due to earthquakes. Many of the dislocations of the strata now seen on land originated when they were beneath the sea, and it would be a mistake to attribute any considerable part of these movements to seasonal or meteorological influences. It may be that the shape of the two sides of a valley undergoes an infinitesimal deformation from these causes, yet no important effects depend on such small deformations. They are all very superficial in character, whereas the causes which have folded the rocks of the earth's crust have been much more deep seated, and originate principally in earthquakes. When we see folded strata laid bare by erosion therefore we may assign the greater part of such effects to the " gentle warping of the soil " experienced in the dreadful shakings and derangements due to earthquakes of the world-shaking class. In observed plications of the strata earthquakes have supplied the principal part of the disturbing force. The important uplifts have all arisen in this way, and the instability thus resulting has produced the smaller displacements noted where the earth is settling.

The ground is more or less flexible near the surface, and sensible sagging may be produced by loading, but such effects are shallow and small in amount, and it would be a mistake to attribute to this cause important deformations of the strata. Is not such phraseology as the " gentle warping of the soil " therefore very unfortunate and misleading, and should it not be entirely given up?

§ 18. *Radium and other Atomic Sources of Energy.*—In the paper on the " Temperature of the Earth " we adhered to the gravitational theory as the only one which could be subjected to strict calculation. It is of course possible that there may exist in our planet unknown sources of atomic or subatomic energy such as are shown in radium and the related elements, which exhibit similar radio-active properties. At present, however, the amount of these elements known to exist in the earth is excessively small, and although this might account for the earth's internal heat; yet as gravitation is known to be a real cause and has been found sufficient to explain the observed phenomena, it is natural that a known source of energy which can be subjected to strict calculation should be preferred to one which is so wholly unknown.

Thus while we confined our estimates and calculations to gravitational energy, we do not deny the possibility that other sources of energy of an atomic or radioactive character may exist. If such sources really exist, the effect would be to prolong the period of the earth's history since consolidation.

At the present it is impossible to estimate these effects with any approach to accuracy, and we have therefore preferred to await the results of future research.

Our knowledge of radium and the rôle it plays in cosmical development is still much too limited to permit even a rough estimate of the effects of such subatomic energy. But it seems certain that radium has no sensible connection with volcanic eruptions, since in the rocks underlying the great extent of the continents it remains quiescent, and gives rise to no kind of outbreaks, though it may raise slightly the temperature of certain mineral springs. Remarkable as radium is, and wonderful as are its chemical actions, we are still unable to say that it plays any sensible part in cosmical processes outside of chemical transformations which lie in the domain of Mineralogy. The energy liberated in these transformations might, however, greatly prolong the past history of the earth, and the total duration might thus be extended from 10 to 100 million years.

III. On the Disturbances of the Earth's Magnetism by Earthquake and Volcanic Phenomena.

§ 19. *Observations Show That Earthquakes and Volcanic Outbreaks Often Disturb Terrestrial Magnetism.*—It has long been noticed that volcanic outbreaks and also earthquakes are not infrequently accompanied by temporary disturbances of the earth's magnetic field. The cause of this is not yet understood and any conjecture at this time may be premature, nevertheless we are inclined to call attention to certain features of these phenomena which should be borne in mind.

1. As the earth's crust is thin, and the interior at an immense temperature, it seems highly probable, if not certain, that the magnetism of the globe depends upon the crust and the atmosphere, together with the sun's variable magnetic field in which our planet

revolves. That the incandescent nucleus could effect the magnetism of the earth seems highly improbable.

2. The annual and diurnal variations of the magnetic needle are most easily explained by the seasonal and diurnal effects of the sun, exerted indirectly through the paramagnetic medium of the atmosphere, the electric forces of which are modified by the sun's varying radiation of charged particles.

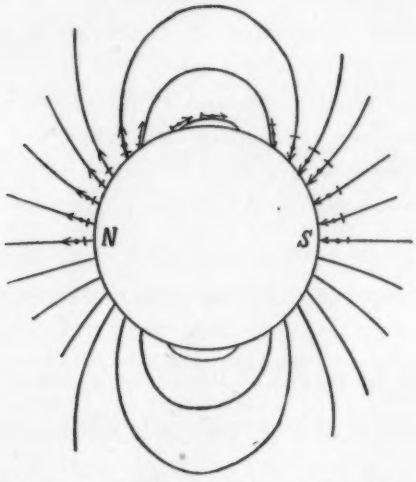


FIG. 4. Showing the lines of force about a spherical magnet, or a magnetized spherical shell, such as the crust of the Earth.

3. The aurora is one of these effects and has been treated by Arrhenius with characteristic penetration.

§ 20. *Gauss' Analysis of the Earth's Magnetism and the Conclusions Which May be Drawn From it.*—If we denote by $d\mu$ the quantity of magnetism present in an element of space, and by ρ its distance from any point in space, whose rectangular coördinates referred to any system may be x, y, z; then we have for the potential function of the earth's magnetism

$$V = \int \frac{d\mu}{\rho}, \qquad (1)$$

where the integration is to be extended over the entire volume of the earth. The forces resolved parallel to the coördinate axes are

$$-\frac{\partial V}{\partial x}=\xi, \quad -\frac{\partial V}{\partial y}=\eta, \quad -\frac{\partial V}{\partial z}=\zeta, \tag{2}$$

and the resulting force is given by the diagonal of the parallelopipedon

$$f=\sqrt{\xi^2+\eta^2+\zeta^2}. \tag{3}$$

If the direction and intensity of the force is found by observation all the desired elements may be calculated.

Passing to polar coördinates Gauss denotes by r the distance of the point from the center of the earth, and by u the angle which r makes with the north polar axis, and by λ the angle with the meridian made by a plane passing through the point and this polar axis. Symbols with subscripts zero refer to points in the earth.

Hence the expression for the distnce ρ from any point in space is

$$\rho^2=r^2-2rr_0[\cos u\cos u_0+\sin u\sin u_0\cos(\lambda-\lambda_0)]+r_0^2. \tag{4}$$

Accordingly the expression for the potential becomes

$$V=\int\frac{d\mu}{\sqrt{r^2-2rr_0[\cos u\cos u_0+\sin u\sin u_0\cos(\lambda-\lambda_0)]+r^2}}. \tag{5}$$

Considering the earth to be a sphere of radius a Gauss puts

$$-V=\frac{a^2}{r}P^0+\frac{a^3}{r^2}P'+\frac{a^4}{r^3}P''+\frac{a^5}{r^4}P'''+\cdots; \tag{6}$$

the coefficients, P^0, P', P'', etc., are functions of λ and u only.

If we develop the denominator under the integral sign in (5) in a series, the first two members of the series become

$$\frac{1}{r}+\frac{r_0}{r^2}[\cos u\cos u_0+\sin u\sin u_0\cos(\lambda-\lambda_0)]+\frac{r_0^2}{r^3}+\cdots, \tag{7}$$

whence

$$a^2P^0=-\int d\mu, \quad a^3P'=-\{\alpha\cos u+\beta\cos\lambda+\gamma\sin u\sin\lambda\},$$

where

$$\alpha=\int r_0d\mu\cos u_0, \quad \beta=\int r_0d\mu\sin u_0\cos\lambda_0, \quad \gamma=\int r_0d\mu\sin u\sin\lambda. \tag{8}$$

As Gauss took the northern and southern magnetism to be equal and of opposite sign, it follows that

$$\int d\mu=0,$$

and $P^0 = 0$. Hence we may put for points at the earth's surface, where $r = a$, and $P^0 = 0$.

$$-V = a(P' + P'' + P''' + \cdots), \qquad (9)$$

where P', P'', P''', depend only on u and λ.

The magnetic potential for the earth calculated in this way represents observations with the desired accuracy. Since Gauss showed that any distribution of magnetism within the earth, as respects the effects in outer space, may be completely represented by an appropriate surface distribution, it follows that the existing distribution of the earth's magnetism is most probably confined to the crust of the globe. In fact this is the only part of our planet sufficiently cooled to maintain magnetic properties once established in its elements. The field of force thus arising about the earth might, however, be slightly modified by electric and other effects depending on the sun and moon, and the diurnal movement of the illuminated hemispheres of our globe. These effects as determined by observation are much too large to be ascribed to direct actions of the sun and moon, and are believed to be indirect effects depending largely on charges operating in the upper regions of our atmosphere.

This upper atmosphere is always exposed to the radiation of the heavenly bodies, and no doubt accumulates a potential powerful enough to influence the field near the earth's surface. Discharge of this potential is witnessed in the aurora borealis, which is accompanied by conspicuous disturbances of the earth's magnetism. Gauss showed that the location of the constant part of the earth's magnetism must necessarily be in the body of the globe, and not in the atmosphere or outer space.

In his "Algemeine Theorie des Erdmagnetismus," 1838, Gauss treated of a sphere magnetised in any manner. If X, Y, Z, be the components of the earth's resultant magnetic force at any point on the surface, in the directions of geographical north, west and the zenith of observer, the horizontal intensity H, declination δ, and inclination ι, are fully defined by the equations:

$$H = \sqrt{X^2 + Y^2}, \quad \tan\delta = \frac{Y}{X}, \quad \tan\iota = \frac{Z}{\sqrt{X^2 + Y^2}}. \qquad (10)$$

If V be the magnetic potential of the earth, l the latitude, and λ the longitude of any point on its surface, and if a be the radius of the earth assumed to be spherical, we shall have

$$X = -\frac{1}{a}\frac{\partial V}{\partial l}, \quad Y = -\frac{1}{a\cos l}\frac{\partial V}{\partial \lambda}, \quad Z = -\frac{\partial V}{\partial r}, \qquad (11)$$

where r is the distance of any point from the center of the earth.

If $S_1 + S_2 + S_3 + \cdots S_i$ be a convergent series of spherical surface harmonics defining for every point of its surface the potential of all the magnetized molten or electric currents within the earth, the potential at all external points will be given by the series

$$V = S_1\left(\frac{a}{r}\right)^2 + S_2\left(\frac{a}{r}\right)^3 + \cdots + S_i\left(\frac{a}{r}\right)^{i+1}, \qquad (12)$$

The functions S_1, S_2, S_3, . . . are functions of known form, containing 3, 5, $\cdots 2i + 1$ constants; and if we neglect terms beyond the ith order, there will remain in the expression for V $i^2 + 2i$ arbitrary constants. These constants may be determined by observation, and then the magnetic action at all points on the surface or outside the earth becomes known irrespective of the internal distribution of the magnetic causes which are inaccessible to observation.

§ 21. *The Mutual Potential Energy and Mutual Action of Two Magnetic Systems.*—If any portion of the earth's crust or an atmospheric current above it should be suddenly magnetized by an instantaneous charge of electricity or otherwise, during the violent commotion of an earthquake or volcanic outburst, we should have at least a temporary magnet suddenly formed in the field of the earth's magnetism, and the result would be the disturbance of the magnetic needle. Whether the magnetism of the earth be distributed according to Poisson's theory, with a certain volume distribution of density v and a surface distribution of density σ; or according to Gauss' theory, with a distribution wholly on the surface, this result is equally true.

To determine the mutual action of two magnets on each other requires the evaluation of a sextuple integral, every point in one field of space acting upon the corresponding points of the other. If W be the potential energy of the whole magnetic system, R and R'

the resultant forces at any point of space due to the acting and acted-upon systems respectively, θ the angle between their directions, and dv the element of volume occupied by any element of magnetism, we have (Encyclopedia Britannica, article "Magnetism," p. 230):

$$W = +\frac{1}{4\pi}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} RR' \cos\theta dv. \qquad (13)$$

Now unless R or R' is zero, so that the elements of the triple integral vanish, or one of the magnets exerts only an infinitesimal force upon the other, this mutual potential energy is always finite. Accordingly, whenever a new magnet of sensible power is suddenly developed in the field of the earth's magnetism, the magnetic needle necessarily is disturbed, as in earthquakes and volcanic outbursts. The fact that such disturbances are so repeatedly observed, leaves no doubt of the development of temporary magnets in the earth's field of force; and the intensity of the disturbance necessarily is greatest near the place where the second magnet is developed. Hence the disturbance of the needle by such outbreaks indicates the generation of temporary magnets in the earth's crust, and especially in the atmosphere. The dissipation of the charge restores quiescence to the earth's magnetic field, and the needle ceases to tremble.

§ 22. *Terrestrial Magnetism Modified by Irregularities in the Earth's Crust.*—In the *National Geographic Magazine* for September, 1907, Dr. L. A. Bauer has a review of the work done by the *Galilee* in the survey of the North Pacific ocean authorized by the Carnegie Institution. After describing the work already done he adds:

> "An all-sailing vessel, however, does not permit the magnetic survey to be undertaken with the completeness and success demanded, since with such a vessel it is more or less dangerous to investigate the magnetic irregularities almost invariably shown to exist near land masses. The mapping of these irregularities is of the greatest importance to the mariner, as in many cases they are sufficient, if not allowed for, to land a vessel on the rocks."

The land masses accessible to the navigator are either islands or shores, and thus irregularities of surface like the mountains which we see on land; and the change in the magnetism near mountains is also well known. It follows therefore that irregularities of sur-

face sensibly affect the magnetic needle in the neighboring region. This conspicuous effect would not be likely to arise if the magnetism depended on the whole earth, rather than on the crust, and hence it seems to indicate that the seat of the earth's magnetism is essentially shallow. Not only may we attribute the permanent magnetism to the crust, but we may also affirm that the upheavals of the crust which have produced mountains have given rise to variations of the local field.

Just how this arises may not be affirmed with entire certainty; but the fact that disturbances have been noted during earthquakes would seem to indicate bodily movement of magnetic matter, or ordinary matter temporarily rendered magnetic.

The outburst at Mt. Pelée, May 8, 1902, which instantly disturbed the magnetic needle over a wide area, was probably due to the ejection of a great mass of burning vapor high into the air, which thus gave rise to such electric energy that the earth's magnetic field was suddenly disturbed.

The eruption at Krakatoa produced a very similar effect, the sudden development of an atmospheric charge vastly exceeding that due to the greatest hurricane. (Report of the Krakatoa Committee, Royal Society, 1887.) A hurricane develops gradually and the effect is scattered over a wide area; a volcanic outburst is sudden and so concentrated that a considerable disturbance of the earth's magnetic field may easily result. It is somewhat analogous to the aurora borealis, but the location and cause is different and the effect may be less rapid. In the aurora there is a discharge between the upper and lower regions of the atmosphere, and this redistribution of the magnetic tension in the earth's atmospheric system causes a fluctuation of the magnetic needle, or a so-called magnetic storm.

Now in the case of a violent volcanic outbreak there is a similar disturbance, owing to the sudden injection of a highly electrified charge into the lower parts of the atmosphere, and the exchange with the upper region continues for some time. Also when great earthquakes occur there is violent shaking of a considerable region of the earth's crust, and consequently some temporary, and perhaps permanent, derangement of the elements of magnetism, owing

to the agitation and to the movement of streams beneath the crust. These seem to be the most probable causes of the changes in the earth's magnetic field, often noticed to disturb the needle at the time of earthquakes and volcanic eruptions; but our knowledge of the subject is still in its infancy and we must be cautious in drawing conclusions. Some of the disturbances of course are purely mechanical.

The comparatively slow propagation (868 miles per hour) of the magnetic disturbance at the time of the Krakatoa outbreak, August 27, 1883, might be ascribed to the undulatory commotion in the upper air, since sound so propagated would have about this velocity. It would seem to depend more upon the indirect effects of a disturbance of the air than upon the forces exerted by a direct magnetic charge. Both causes are no doubt at work in certain disturbances, and time must decide just how the effects are propagated.

Conclusion.

At the close of the two former papers on the physics of the earth, the chief results at which we arrived are briefly summarized. In the same way we may here add a recapitulation of the results which are more fully established in this third paper.

1. It has long been customary to refer mountain making to catastrophes in remote geological ages, and to suppose that the formation of mountains is not going on upon the earth at the present time. Such supposed spasmodic activity is contrary to the whole order of nature and to the doctrine of evolution by which we labor to interpret animate and inanimate phenomena. On the other hand the discovery of mountains in the depths of the sea has excited the surprise without satisfying the wonder of the naturalist, so that the whole subject has become involved in darkness.

2. The doctrine of continuity, as respects both time and space, permits us to view earthquakes, mountain formation, and kindred phenomena, merely as a part of an unbroken whole which has come about by the steady action of natural laws operating not only along the borders of the continents, but also in the depths of the ocean. A theory which unites and harmonizes these phenomena,

and thus explains the mountains on land, as well as those in the depths of the sea, by a common cause, operating not only throughout past geological ages, but also at the present time, will naturally have a strong claim to acceptance.

3. We have therefore labored to establish some undeniable cases of mountain formation now going on in the depths of the sea, and have shown by the theory of probability, based merely on contiguity of positions and similarity of volume between the deep trench off the Aleutian Islands and the ridge which runs parallel to it, with peaks here and there projecting above the water as islands, that the chances are at least a decillion decillions to one that the ridge and adjacent depression are physically connected and have had a common origin. As an island of the ridge is frequently uplifted by an earthquake, while the bottom of the trench sinks, as shown by the withdrawal of the water before the inrush of the accompanying seismic sea wave; and as this corresponds to an expulsion of lava from beneath the trench towards the land, or away from the body of the Pacific ocean, and the volume of the ridge corresponds to that of the trench, the probability that one developed from the other is converted into an absolute certainty.

4. The expulsion of lava from the ocean towards the land and the breaking out of numerous islands into volcanoes, emitting chiefly vapor of steam, shows that the subterranean movement can depend on nothing whatever but the secular leakage of the ocean bottom, which is most rapid where the sea is deepest, in accordance with the observed recurrence of earthquake phenomena.

5. Undeniable cases of mountain formation now going on in the depths of the sea may thus be located in various parts of the world. We have cited such cases in the Aleutian, Kurile, and Japanese islands; in the East Indies, between New Zealand and Samoa, and along the coasts of various continents. Many more may be found by the further study of the sea bottom and of the earthquakes now disturbing it.

6. It thus seems undeniable that earthquakes in the sea and along the sea coasts have the highest geological significance. In fact no other forces are at work crumpling the earth's crust, as seen in mountain ranges, islands, and plateaus; and the absence

of mountain forming movements in the interior of the continents shows that all these effects depend upon the sea, or upon surface water generally, and not at all upon the progress of the secular cooling of the globe.

7. Researches into the physics of the earth based on the hypothesis of gravitational instability may be interesting mathematically, but a study of the earth's surface shows that all the important crustal movements now going on result from the influence of the sea; and hence the conclusions deduced from the theory of gravitational instability are invalid, because, ingenious and correct as they are on the hypothesis, they rest on a false premise.

8. In the same way it is shown that no sensible shrinkage results from secular cooling; on the contrary the globe seems to be undergoing a gradual secular expansion, owing to the influence of the sea in uplifting mountains, plateaus and other masses of land, by the injection of lava saturated with steam, which forms underlying masses of pumice of various degrees of density. The expansion of the globe seems to be at least ten times more rapid than the contraction due to secular cooling; and the great distance to which the sea has withdrawn from some of the mountain ranges, and the great height to which the plateaus have been uplifted, exhibits the mighty effects of this cause in the course of geological ages.

9. The seat of terrestrial magnetism seems to be the earth's crust and the surrounding atmosphere; irregularities in the magnetic forces arise from the sun and moon, while similar disturbances accompany earthquakes and volcanic outbreaks, which suddenly agitate the air and change the electric condition of matter in the field of the earth's magnetism. The irregularities near islands and land masses noticed in ocean surveys indicate that the permanent magnetism is confined chiefly to the solid crust, and does not depend on the great incandescent nucleus of the globe. Magnetic storms and aurorae depend on atmospheric charges derived principally from the sun and moon.

10. It is thus proved not only that earthquakes, volcanoes, mountain formation, the formation of islands and plateaus, seismic sea waves, and the feeble attraction of mountains long noticed in

geodesy, are closely connected and mutually dependent upon a single physical cause, namely the secular leakage of the ocean bottoms; but also that the magnetism of the earth is intimately connected with the forces which modify the earth's crust, because the chief seat of the permanent magnetism is shallow. Thus seven great classes of natural phenomena are shown to be mutually connected and dependent on the forces which have crumpled the crust of our planet.

11. In the paper on the temperature of the earth it was shown from the mathematical theory of heat as applied to the secular cooling of the globe that when the gravitational potential of the mass alone is the source of energy considered, the most probable age of the consolidated earth is some ten million years. Variations of the data there used might possibly double this age, but it is doubtful if further extension of the time limit of the past history of our planet is possible without invoking the aid of subatomic energies as exemplified in radium and kindred radio-active substances. At present we know too little of radium and similar elements to be able to affirm with confidence that the heat resulting from the transformation of these substances does not prolong the life of our planet; yet as radium has no known connection with volcanoes, earthquakes, and mountain formation, but, from the absence of outbreaks in the interior of continents, seems to be everywhere in an essentially quiescent or dormant condition, it is natural to infer that it plays only a subordinate part in cosmical processes. It may, however, be of great importance in chemical transformations, which belong to the domain of Mineralogy, and relate to the crust, rather than to the body, of our globe. Without, therefore, wholly denying the cosmical importance of radium, we calmly await developments which will show its correct place in the order of nature. As the energy derived from radium would counteract the effects of secular cooling it may have greatly prolonged the history of the encrusted earth.

12. In the investigation of phenomena so complex as those connected with the physics of the earth, we must not expect the real underlying physical cause to be entirely clear in every case, because the present state of the globe presents to our contemplation natural

processes in every stage of development, and the aspect obviously will be different in different stages. If we can find the true laws exemplified in a few typical cases in which the meaning of the phenomena is free from doubt, we may legimately hold that in all cases the phenomena were more or less similar at one stage of their existence. Considering the vast age of the earth and the insignificant period of human history, and the much briefer time covered by intelligent observations, we seem indeed fortunate to be able to recognize the true processes in even a few typical cases of crustal transformation. For the life of the individual is as nothing in the history of our planet. Accordingly the simplest natural laws, which lie at the basis of the physics of the earth, we have discovered and confirmed beyond all doubt; and we may safely leave to the future the extension and verification of the theory of the secular leakage of the ocean bottoms, of which we have been able to lay only the general foundation.

But even a mere outline of the processes which lie at the basis of the physics of the earth is likely to clarify and simplify our views of the order of nature. The complete development of that beautiful science will be a work of the future, and for the present we must rest content with the recognition of true physical causes, without which order and harmony and proper relationship between different classes of phenomena could not be established, however great the number of observations. The chief danger in science to-day is that in the midst of such vast multitudes of special observations as are being accumulated, the few true causes, which give order and harmony to the whole body of phenomena, will be lost sight of. Without these underlying principles for guiding our thought, according to nature's laws, the mere accumulation of disconnected facts may become a burden to oppress, rather than a starry ray to illuminate, the human mind. Principles are therefore vastly more important than observations, though accurate observations always are required in their deduction; because where the underlying laws are confirmed they give the solid foundations for a real science, which enable us to understand the observations of all time.

Blue Ridge on Loutre,
Montgomery City, Missouri, October 24, 1907.

Addendum.

§ 23. *On the Sinking of Deep Trenches in the Sea Bottom.*—Since the above paper was finished it has occurred to the writer to point out a little more clearly the circumstances which may lead to the sinking of the sea bottom, when lava is expelled from beneath it. In the accompanying figure, the process of mountain formation is supposed to be going on. The expulsions of lava naturally are accompanied by a sudden relief of crustal stress, and a mighty horizontal thrust in the direction of the movement, as the lava is pushed under the land.

This terrific lateral pressure is powerful enough to push the lava along under the crust, in spite of the great weight of the latter. By this enforced movement the ridge is elevated, as at *b*, and at the

same time the crustal block moved a good many feet in the direction of the land; this stretches the sagging crust, and pulls it apart along certain fault lines under the sea, as at *a;* so that when some of the support from beneath is withdrawn by the expulsion of part of the supporting lava, and the fault opened, by the horizontal movement, the crust naturally gives down. The shaking accompanying the horizontal thrust of the crust opens the fault under the sea, thus temporarily removing the friction of one crustal block against another and permitting the walls to slide without great resistance. And as the support is weakened by the simultaneous expulsion of part of the underlying lava, sinking necessarily follows.

From these considerations we see that sinking is most easily brought about where the ridge is sharply elevated so as to permit some lateral movement. It is true that the inclination of the crustal block throws a little more weight on the side under the sea and this would increase the resistance; yet when the fault is opened during the vibrations of an earthquake sinking the more easily takes place. This explanation enables us to understand why sinking of the sea

bottom, as shown by the accompanying seismic sea wave, so frequently occurs during great earthquakes.

The force of the argument that the ridge was uplifted by matter actually expelled from under the trench is easily seen from a familiar illustration often met with in a smooth field or on the plains. If we go along over the level ground, and all of a sudden come upon a mound with a sink hole near it of about the same volume, we immediately conclude that the mound builders or pond diggers have been at work. It is obvious that the mound is made of soil which came out of the hole. In the same way, if we came upon a ditch with a ridge to one side, of such volume that it would about fill up the former, we know with even greater certainty that ditch diggers have taken the soil out of the trench and piled it upon the bank.

Now the trenches in the sea bottom, with parallel ridges of nearly equal volume, have all the force of this familiar argument; but as they have not been dug from above, it follows that the matter is transferred beneath the crust, by subterranean bodily movement of the kind we have described; and hence the crust has been crumpled correspondingly, the ridge running parallel to the trench from which the matter was expelled.

§ 24. *On Darwin's Theory of Coral Islands.*—This investigation throws decided light upon Charles Darwin's famous theory of the sinking of the ocean bottom, as inferred from the study of the coral reefs. It shows that while sinking often takes place, elevation also is very common. The chief difference is that elevation kills the coral, and the islands gradually become covered with vegetation, while only those in which sinking predominates become surrounded by coral reefs. It is well known that there are many islands in the sea with coral rock above the water; a good illustration is afforded by the eastern end of Guam, where a huge block has been uplifted, as shown by the vertical walls. Islands which have been recently uplifted often are volcanic, so that coral appears especially about old islands, many of which are subsiding, owing to a change in the direction of movement beneath the crust. Forces which formerly produced elevation are now changed in direction and working so as to produce a slow subsidence. Charles Darwin's theory of coral reefs is therefore confirmed, but it does not explain all the phe-

nomena noticed about the islands in the sea. It happens also that some islands once built around by coral are again upraised by a recurrence of the elevating movement; yet this probably would not be the usual phenomenon, so that in general Darwin's observations on coral reefs accord with the theory, and are what one might naturally expect to find on an ocean-covered planet with leaky and oscillating crust.

§ 25. *On the Modification of Secular Cooling by Radium.*—In regard to the age of the earth, it ought to be remarked that if radium be taken into account, the heat resulting from its secular disintegration would prevent the crust from thickening, except very slowly; and consequently with so thin a crust as that of our actual globe the period of time since the consolidation, as calculated in the paper on the "Temperature of the Earth," is too small. Accordingly although we found the period to be of the order of ten million years, yet if radium be introduced the duration of time might be lengthened to one hundred million years, or even to a greater period. And if this energy due to radium be admitted for the earth, it could not well be denied for the sun, so that the period of the sun's activity would be lengthened correspondingly. Hence the more moderate of the immense periods of time demanded by geological phenomena may be conceded. Time must decide to what extent these demands are justifiable. At present we may await future developments with entire confidence that the causes now known are sufficient to explain all terrestrial phenomena.

§ 26. *Favorable Reception of the Present Theory by Physicists and Geologists.*—The lively interest awakened by the two preceding papers among physicists and geologists and other men of science, as shown by letters which have reached the writer, indicates a much more favorable reception of the present theory than might have been anticipated. Indeed its general acceptance seems fully assured, and many questions are thus raised of great importance in natural philosophy. All who have considered the question attentively seem to agree that it is very improbable that the ocean bottom is water-tight. One of the most eminent of living physicists expresses the opinion that this cannot be true, unless the nature of the rock is greatly modified by pressure. Such modification under pressure he

thinks cannot take place in the first twenty miles of the earth's crust, because the pressure is not great enough to prevent secular leakage under the constant pressure of the oceans, which in many places is sufficiently powerful to throw a column of water five miles high.

No doubt this view will be generally adopted by physicists and geologists. One may indeed see that it is true by remembering that at a depth of twenty miles the pressure is only about 8,600 atmospheres, or a little over eight times what it is in the deepest oceans. Such pressure might indeed tighten the crystalline elements of granite, but it could not obliterate the crystals; and hence capillary forces would be intensified rather than diminished by this tightening up of such a coarse-grained structure.

We cannot experiment on rock subjected to such pressure as exists at a depth of twenty miles, but we can observe lava expelled from volcanoes, some of which was once compressed at this depth; and we can examine the granite at the base of vertical walls where faults have moved under earthquake forces for many thousands of feet. In neither case does the structure of the rock indicate that great modification would occur at so small a depth as twenty miles.

But the most conclusive answer which nature gives to this inquiry is furnished by the vast vertical walls of granite so often lifted thousands of feet by fault movements in such places as the Andes of Peru, Chile and Patagonia, where the leakage of the ocean has found relief by the expulsion of lava under the land along the margins of the sea. The meaning of the mountain formation along such a sea coast admits of no possible doubt. Accordingly we are enabled to interpret the movements beneath the crust, and to infer the nature of the underlying rock, even where it is wholly inaccessible to observation.

Blue Ridge on Loutre,
Montgomery City, Missouri,
Jan. 14, 1908.

ERRATA.

(*a*) In the paper on the CAUSE OF EARTHQUAKES:

On page 311 the formula for n should read $n = \frac{4400}{66} = 66\frac{2}{3}$.

The account of the changes produced by the Valparaiso earthquake, p. 328, appear to be open to some doubt. Exact data are not yet at hand. This detail of course does not affect the argument in the paper.

(*b*) In the paper on the "Temperature of the Earth":

(1) On page 196 the formula should read $\frac{Q}{W} = \frac{k - \epsilon}{k - 1}$.

(2) Near bottom of page 196, and middle of page 197, Auwendungen should read Anwendungen.

(3) On page 216, $\frac{d\theta}{dx}$ is taken to be $\frac{1}{51}$; and the exponential factor is neglected, because it appears in the second power, and for a depth of twenty miles is equivalent to $e^{-\frac{10^{20}}{(16)^2 10^{20}}} = e^{-\frac{1}{256}}$ and thus nearly unity for $t = 100{,}000{,}000$ years; for $t = 10{,}000{,}000$ years, the result is $e^{-\frac{1}{2.56}} = \frac{1}{1.48}$, which would make t still smaller, in the ratio of nearly 2/3 (0.676). There is therefore a slight defect in the solution for values of t so small as 10,000,000 years; but as it reduces the time to a still smaller interval, we need not further consider it. The values of t given in the paper on the "Temperature of the Earth" are therefore slightly too large for rigorous solutions of the equations.

SOME OF THE RESULTS OF ASTRONOMICAL PHOTOGRAPHY PERTAINING SPECIALLY TO THE WORK WITH A PORTRAIT LENS.

(Plates I–VI.)

By E. E. BARNARD.

(*Read April 20, 1907.*)

In the present paper I wish to offer a few specimens of astronomical photographs which have been made with portrait lenses. These pictures, which are from my own work, are fair samples of what can be done with this class of lens. They have been selected to show the variety and extent of the work, which covers the Milky Way, the nebulæ, the larger star clusters, meteors, comets, the earth-lit and the totally eclipsed moon, etc. Most of the pictures were made with the 10-inch Brashear lens of the Bruce telescope of the Yerkes Observatory.

The Advantages of Photography in Astronomy.

Before the application of photography to the study of the heavens, one saw the sky but poorly indeed, and in the light of the revelations of the photographic plate today, one is almost tempted to say that he did not see the heavens at all, so vastly has photography enlightened us as to the actual appearance of the sky and its citizens.

There are two causes that have helped to produce this wonderful power that photography has given us. First, above all, the great sensitiveness of the photographic plate over that of the human eye. Second, the fact that our plates show us a vastly larger space of the heavens than the visual telescope does—in some cases a thousand times greater than is shown by our most powerful telescopes of today. A wide field of view is of the utmost importance in the study of the tails of comets, of the larger nebulæ and of the

cloud forms and structure of the Milky Way, for these in general are very large. The field of view of a visual telescope, which is at most but a mere speck of the sky, is entirely too small to take in the whole of such an object. In the case of the Milky Way, the structural details are on such a grand scale that their true forms could not even be guessed at with the ordinary telescope. The importance, therefore, of the large field that the photographic plate gives us is very evident.

But there is one thing which we must take into account. The time element enters strongly into the photographic part. One may look into a telescope and he will see at once, if the conditions are favorable, the faint star or faint nebula he has in the field of view—it is but a moment that the eye takes to fix the image before it. Perhaps some very faint and difficult object may require a little longer, but it is only because a special moment of steadiness is waited for. The photographic telescope with its highly sensitive plate will not catch the object in that same time. It may require an hour or more before it "sees" it. But with the eye there is no cumulative effect; on the contrary, indeed, it soon becomes tired, so that in a sense, the longer you look the less you see, merely from the fatigue of the eye. With the plate there is no fatigue. The longer it looks the more it sees, so, though it may take it an hour to see what the eye readily perceives in a moment, it does not stop at that point but goes on seeing more yet, the longer it looks. In this way it soon registers things that the eye cannot perceive at all with equal optical means, and in many cases it reveals objects—especially among the nebulæ—that the eye may never see in the actual sky. And, what is of immense advantage, it permanently records what it sees, so that the exact appearance of a nebula may be preserved for future reference perhaps hundreds of years hence, while the view obtained by the eye is as evanescent as the fleeting glimpse of the object itself. Even though the observer should make a careful drawing it is too often worthless, and misleading, for reference with other drawings, made later on; for the astronomer is seldom or never an artist.

If one examines drawings of the same celestial object by different observers, he is often struck with the want of agreement in

these pictures. There are a few of the more prominent nebulæ such as the celebrated ones of Orion and Andromeda, which have been drawn by many observers. There is a strange want of resemblance among these pictures, and what is worse still there is often but little resemblance to the object itself. There was always the possible excuse that the object had actually changed its appearance in the sky. Photography, however, in the past twenty years has shown that such appreciable changes have not really occurred, though they must occur in the course of time.

The best illustration of this want of harmony in different delineations of the same astronomical subject is shown in the large number of drawings of the solar corona made by numerous observers at the total eclipse of the sun in 1878 which were collected and published by the United States government. No two of the forty odd drawings closely resembled each other and few of them looked at all like the indifferent photographs obtained at the time. Indeed these drawings and other similar ones led an eminent astronomer four years later to declare that the corona was not a real phenomenon belonging to the sun, but that it was partly a diffraction effect and partly in the eye of the observer, so that each observer, as it were, saw a different phenomenon—an idea that no one would think of holding today when photography has long since clearly demonstrated the solar origin of the corona.

The real cause of these various discrepancies lay mainly in the want of artistic skill in the observer, who saw the things all right but was unable to draw them correctly, especially was this so in the case of an eclipse of the sun, where the excitement of the moment was enough to unnerve most observers.

Perhaps the greatest sufferer from this want of pictorial skill was the occasional comet. These bodies are really subject to remarkable and rapid changes and hence a misrepresentation was all the more unfortunate. In the case of the nebulæ one could simply throw out the poor representations as being due to lack of skill. In the case of the comet no one can tell whether the want of agreement in the various drawings was not due to actual changes in the comet itself. Happily today, the lack of artistic skill in the individual plays almost no part in astronomical work. The photo-

graphic plate, not only with an accuracy far beyond that of the most skillful artist, but with an eye almost infinitely more sensitive, sees the faintest details of a comet or a nebula and records them with a faithfulness unheard of before.

Today the sensitive plate is not only taking the place of the astronomical draughtsman, but it is also running the most skillful measurer a close race. The facility and ease with which great numbers of star places can be measured on the photographic plate, commend it to the most exacting astronomer.

Photography has materially altered our ideas of the nebular theory. From the views of the nebulæ with telescopes not sufficiently powerful to properly deal with them, and hence with views that were more or less erroneous, a theory was elaborated that appealed to the popular mind with a wonderful fascination. There is much that must be changed in this theory to meet the rigid requirements of modern science and to satisfy the demands of what has been revealed in the forms of the nebulæ by the photographic plate.

It is in dealing with the nebulæ that astronomical photography has attained one of its most remarkable triumphs. These bodies in reality shine with a light that has comparatively little effect on the human eye but to which the photographic plate is singularly sensitive. To our eyes the nebulæ are seen "through a glass darkly," as it were, while to the eye of the sensitive plate they are more or less brilliant objects.

Our old ideas of the dimensions of these vast bodies have also been greatly changed. In the days of purely visual astronomy, the great nebula of Orion, covering as it does some half a degree of the sky, was looked upon as inconceivably great in actual extent in space —yet photography has not only increased its extent very greatly, but it has revealed other nebulæ, unknown to us before, that are hundreds of times vaster than this great nebula of Orion. The Pleiades are in the midst of a mighty system of nebulosity that covers at least one hundred square degrees of the sky, and whose actual extent in space almost defies calculation.

Four or five degrees north of the star Antares, in the Scorpion, is a faint star just fairly visible to the naked eye. This is known

as Rho Ophiuchi. If one examines the space about this star with a telescope he sees nothing remarkable except that there are fewer small stars in this region—yet photography shows us that the sky here is covered by an enormous and magnificent nebula which apparently lies in a hole in the sky. From this great vacant region—vacant in the sense of there being few or no stars in it—narrow dark lanes run eastward for many degrees. But the singular thing is that the nebula seems in some way to be responsible for the absence of stars at this point. Whether this is due to the obscuration of the light of the small stars that ought to be here, by the nebula, which would in that case prove it to be nearer to us than the stars, or whether the presence of the nebula has in some way destroyed or dispersed the stars cannot be told.

Perhaps the most extraordinary revelations of photography in astronomy have been in the case of comets. These wonderful objects with their vast trains sweeping through space are singularly subject to disturbances by other celestial bodies. The photographic plate has shown us that the comets utterly transform themselves in a few hours' time, for, though of vast dimensions, they are in reality but flimsy affairs with little or no solidity. In these changes, so faithfully recorded by photography, they sometimes, through the distortions of their trains, reveal the presence of some kind of resisting medium or of some unknown bodies through whose attraction, or by collision with which their tails are twisted, broken or deformed in the most extraordinary manner. This was the case with one of the comets of 1893 where photographs on successive nights show the tail disrupted and broken, undoubtedly by such an encounter. What this really means we have yet to learn. Possibly the comet passed through a dense swarm of meteoric bodies in its flight around the sun. Photographs of another comet showed the tail entirely separated from the head and drifting away in space. From these last pictures it was shown that the particles forming the tail were leaving the comet with a velocity of twenty-nine miles a second.

Importance of the Portrait Lens.

The strangest thing in connection with these statements is that the greater portion of these photographic revelations have been made

with instruments that are extremely crude in comparison with the elaborate and expensive telescopes with which our great observatories are equipped today. Indeed in many cases the lenses were not made for the purpose to which they have been put. It was only incidentally that their services came to be of benefit to astronomy. I have often thought of the strange difference in the present use of these lenses and the one for which they were originally made. Though it would be hardly fair to attribute their origin to the purpose of human vanity, it was certainly vanity that had much to do with it, for these large lenses were made purely for the taking of portraits. In the days of the wet plate process the slowness of the sensitive agent used in the plates made it necessary to employ very large lenses so as to collect a greater quantity of light, and thus to shorten the time of the sittings. Their use has therefore not fallen to a lower level but has risen to a much higher one—from the picturing of human vanity in the human face to the picturing of the sublime features of the face of the heavens. Their great light grasping power is no longer needed for the enlightenment of human vanity—not that that evil has in any way become extinct—but from the fact that with the extremely rapid dry plates of today the work can be done with very much smaller and less expensive lenses.

Description of Plates.

Nebulæ and Nebulosities.

For an example of nebular photography with a portrait lens perhaps one of the best specimens is that of Plate I (exposure 4 hours), which shows the "North American Nebula." Though this plate does not represent all that is visible on the original negative, it yet shows how beautiful the nebula is, and how appropriate was Dr. Max Wolf's naming of it. The nebula is not a faint object with a telescope—indeed it was discovered over a hundred years ago by Sir William Herschel. It is not, however, suited for visual observations. With a small telescope one sees only a diffusion of feeble light which has no definite form or limits. It is, nevertheless, excellently and specially adapted for photographic representation because of the peculiarity of its light, which is very rich in photo-

graphic qualities. A long exposure, however, is required to show the fainter outlying masses of nebulosity which are clearly shown in the present picture. This photograph was made with the 10-inch Bruce portrait lens of the Yerkes Observatory in the splendid atmosphere of Mount Wilson, California, where the writer had taken it in 1905, through the courtesy of Professor Hale, for the photographing of the Milky Way.

This picture exemplifies in a striking manner a peculiarity which is often found in connection with these large nebulosities and to which I have frequently called attention. That is, the apparently free mixture of stars and nebulosity without any evidence of condensation of the nebulosity about the stars. I don't think this is necessarily a case of accidental projection of the stars and nebulosity, for there are numerous similar cases in the sky. In the present case one can trace out a similarity of configuration of the outlines of the nebula and the massing of the stars, which would strengthen the idea that they are at the same distance from us. This fine object is in the Milky Way a short distance east of Alpha Cygni, which star is shown at the western edge of the plate.

A good example of the fainter and more difficult nebulosities is shown in Plate IV, the nebulous region of Gamma Cygni (exposure 6 hours 30 minutes). These nebulosities are not visible with the telescope because of their exceeding faintness. Their full extent is not shown in the photograph, for they extend considerably beyond the limits of the plate. It will be seen that Gamma Cygni, the star in the middle of the picture, is in a region of diffused nebulous matter which extends over a large area and is gathered in masses of greater brightness at different points, but is in general formless and diffused.

The lower picture of Plate IV is a still finer example of the photographic nebulosities—*i. e.*, nebulosities that are too faint to be seen with the telescope and for the knowledge of which we are dependent on the photographic plate. This is the magnificent region of the great nebula of Rho Ophiuchi (exposure 4 hours 30 minutes). Unfortunately the reproduction is a failure, for much of the nebulosity and the great vacancies connected with it, that are so wonderfully shown in the original, are all but lost in this half-tone.

I think there is no other region in the entire sky so remarkable as this of which Rho Ophiuchi appears to be the center. The great nebula itself, which seems to cover almost this entire region with its extensions, and its association with the extraordinary star vacancy here are very puzzling, and lead one to believe that the apparent paucity of small stars at this point is due in some way to the presence of the nebula. The great dark lane or rift running to the east, extends as far as the region of Theta Ophiuchi and seems to be a part of the system of vacancies that occur to the east and south of Theta.

The great nebula is full of remarkable details. There are a number of principal condensations, that of Rho Ophiuchi being perhaps the most striking. The nebula extends to, and involves the bright naked-eye star Sigma Scorpii in a strong condensation full of details. In several wave-like masses it involves and reaches beyond Antares, one of the brightest stars in the sky. It seems to faintly cover a great part of the sky here, extending so far north, perhaps, as to connect with the remarkable nebula about Nu Scorpii. There are traces of it extending as far south as Tau Scorpii.

Perhaps as remarkable as anything in connection with this nebula is the fact that it is so faint that the eye, armed with the most powerful telescope, cannot see it. Its light seems to be almost entirely photographic, and though too faint to be seen in the telescope it is doubtless very bright to the photographic plate.

At the lower part of this plate, a half inch to the left of the small cluster (M 4), is apparently an ordinary star. This is the bright red star Antares which is the brightest in this region of the sky, but which, from its red color, appears quite small and insignificant on the photograph. A half inch above the cluster is the star Sigma Scorpii which is much less than Antares. Sigma Scorpii is the center of a bright condensation of the nebulosity which in the original is seen to connect with the larger nebulosity (in the middle of the plate) about the star Rho Ophiuchi. The dark lanes running from the nebula east, though strong and conspicuous in the original, are nearly lost in the reproduction.

The first picture in Plate II is a photograph of the region of the double cluster of Perseus (exposure 5 hours 55 minutes), which

gives a good idea of the gradual massing of the stars from a region of uniform distribution into two clusters whose stars are brighter than the average of that part of the sky.

Meteors.

The unpredicted appearance of the occasional meteor, the suddenness with which it appears and the rapidity of its flight across the sky, make it impossible to locate its path with exactness by eye observations alone; though observers skilled in this class of work can secure a close approximation to the path. If two such observers are separated by several miles, a fair idea may be obtained of the distance of the meteor and of its actual path through our atmosphere. In general, however, there is always much uncertainty attached to such results. What one really sees is a more or less bright point of light darting suddenly across the sky—the duration of whose flight seldom exceeds one second of time and the image of which vanishes from the brain almost as soon as it is formed. It may well be imagined how difficult is the exact location of the path of this fleeting point among the stars. If the meteor could have left a line of light on the sky along the full extent of its course for a few minutes, then one could locate its position fairly with respect to the stars, and yet this would still have considerable uncertainty attached to it from the fact that at best only an estimate (and no measures) could be made with the naked eye of the position.

In photographing the sky with wide angled lenses it is not an uncommon thing for a meteor to take its flight across the region which is being photographed. In this case when it is bright enough, the meteor actually does leave a permanent path among the stars; for the moving point of light affects the sensitive plate, continuously, marking out thus a "trail" among the star images, which is permanent and whose position can be measured with very great accuracy.

If a second camera, some distance from the first one, is also photographing the same part of the sky the meteor trail will be recorded by both cameras and its displacement on the two plates as photographed from these two points on the earth, can be determined accurately and the distance and path of the meteor will become

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known. Such an instance occurred at the Yerkes Observatory where the same meteor was photographed with two cameras (by Mr. Frank Sullivan and the writer) separated by 400 feet only. The parallax or displacement of the trail among the stars was clearly shown. Measures of these two plates show that the meteor was about 90 miles above the earth's surface.

In Plates II and III are given specimens of meteor photographs selected from a great number of such plates. The lower photograph, of Plate II (region of M 11, exposure 2 hours 40 minutes), shows the trails of two meteors which were nearly in a straight line, so that, at first thought, one would suppose it was the trail of one meteor which had been interrupted near the middle of its flight. Both meteors were moving toward the south, it is assumed (for they were not seen by the observer), and were undoubtedly Lyrids —having a radiant in the constellation of Lyra.

Plate III (α 17 hours 20 minutes, δ south 15°; exposure 1 hour 34 minutes) shows in the first case the full flight of a meteor which evidently exploded near the end of its path, as indicated by that portion of the train which is of greater brightness. The lower photograph shows a great meteor trail and Brooks comet, IV, 1893 (exposure 2 hours 5 minutes). The bright trail was caused by a very large meteor which was seen by the observer. It was moving toward the southeast and exploded just off the edge of the plate. By one who is regularly photographing the sky with these rapid lenses, meteors are thus frequently caught in their flight.

Comets.

Plate V shows two views of Giacobini's comet (c 1905). The first of these (December 29, exposure 1 hour 38 minutes) is the most interesting because of the peculiar form of the tail of the comet. The edges of the tail are convex and sharply defined, and they taper to a narrow neck where they join the head, which is quite large. The tail was doubtless a hollow cone. There is a narrow hazy strip running from the lower or south edge of the tail near the middle of the plate. In the original this can be traced across the edge of the tail onto the tail itself. On the next night, December

30, all this definiteness of form had disappeared and the tail was very wide and diffused.

The lower plate (exposure 1 hour) is very interesting, but the main features of the tail are lost in the reproduction. Both photographs have suffered greatly in making the half-tones.

The Lunar Surface under Various Kinds of Light.

Plate VI shows two photographs of the moon. The size of the lunar image on photographs with a portrait lens (a half inch in diameter with the 10-inch telescope) is too small to be of any importance in the study of its crater and mountain-scarred surface. Such photographs, ordinarily, are, therefore, not worth the making. But there are conditions under which the moon may be photographed to advantage with these lenses—nor for a study of the craters and mountains, however. The first of these pictures (enlarged) shows the new moon with the slender sunlit crescent embracing the dark or night part, where no direct sunlight reaches the surface, or in other words it is the "old moon in the new moon's arms," which sometimes forms such a beautiful picture in the western sky at the vanishing of twilight when the moon is but a few days old. With the exception of the bright crescent, what we see is the lunar night, but it is a full "moon" night, for the illumination is entirely by sunlight reflected from the surface of the earth onto the night side of the moon. At that time if one were placed on this night part he would have seen the earth shining in the night sky like a great round moon (nearly full) some thirteen times bigger than the moon ever appears to us. The distinctness with which the lunar surface is shown in the photograph (with only 20 seconds' exposure) gives an idea of how brilliant the full earth must be when shining in the lunar night. This picture was made for comparison with the full moon and with the totally eclipsed moon, for the surface is then shown under three different kinds of illumination, *i. e.,* direct sunlight (full moon) reflected sunlight (earth lit moon) and refracted sunlight (totally eclipsed moon) to see if any difference could be detected in the appearance of the surface as affected by these various illuminations. Portrait lenses are specially suited for this purpose.

The second picture of this plate is a photograph of the totally

eclipsed moon (exposure 9 minutes) in which the only illumination is due to the sunlight refracted through the earth's atmosphere and bent into the shadow of the earth onto the moon. One of the reasons for making this picture was a hope that if any small body should be attending the moon in its journey around the earth (a small satellite for instance) it might be outside the shadow at the time, and being thus illuminated by the sun, would show on the photograph. The moon itself is ordinarily so bright that it would drown out the light of any faint body that might attend it.

Both the photographs of Plate VI are essentially ruined in the reproduction.

List of Lantern Slides.

This paper, when read, was illustrated by a number of lantern slides of the various photographs. A list of these is given below for completeness. I have arranged the slides in the order of subjects.

I. *The Earth-lit and the Totally Eclipsed Moon.*

Slide 1.—The new moon showing the lunar night, illuminated by the "full earth."

Slide 2.—This is the totally eclipsed moon illuminated only by refracted sunlight coming through the dense atmosphere near the earth's surface.

II. *The Milky Way, Star Clusters and Nebulæ.*

Slide 4.—The great star clouds of Sagittarius, east of the Scorpion.

Slide 5.—The double cluster of Perseus.

Slide 6.—The nebulous region of Gamma Cygni.

Slide 7.—The "North American Nebula" in Cygnus.

Slide 8.—The nebulous region of Rho Ophiuchi.

Slide 9.—The nebulosities of the Pleiades. This shows well the remarkable thread-like strips of nebulosity, especially the one from Electra and the one near and parallel to it. The extent of the nebulosities is greater than usually shown in photographs of the cluster. The original negative shows the exterior nebulosities surrounding the cluster. Exposure 3 hours 40 minutes.

III. *Meteors.*

Slide 10.—This shows two large meteors which followed nearly the same path across the plate.

Slide 11.—This shows the full flight of a large meteor on 1898, June 7.

Slide 12.—These two pictures are of the same meteor, but with two cameras 400 feet apart. The small scale picture was made by Mr. Frank Sullivan with 3.4-inch portrait lens attached to the 40-inch telescope during Professor Frost's spectroscopic observations. The other was made with the 6-inch lens of the Bruce photographic doublet. An inspection of the trail with respect to stars near which the meteor passed shows a decided parallax. The distance of the meteor above the earth's surface, from these two pictures, was about 90 miles.

IV. *Comets.*

Slide 13.—Swift's comet on 1892, April 7, showing a large mass and separate system of tails which were going out from the comet.

Slide 14.—Giacobini's comet, 1905, December 29. The picture shows the remarkable appearance of the tail, which on this date was quite unlike the tail of any other comet.

Slide 15.—Borrelly's comet on 1903, July 24. The second photograph on this slide was made by Mr. R. J. Wallace. The interval between the two pictures is 3 hours. The tail which was separated from the comet, had receded noticeably in three hours. Measures of the plates showed that the particles forming the tail were moving away from the comet at the rate of 29 miles a second. (See *Astrophysical Journal,* October, 1903.)

V. *Vacant Regions and Holes in the Heavens.*

Slide 16.—This is a remarkable region of vacancies in a great nebulous background in the constellation of Taurus. (See *Astrophysical Journal* for 1907, April.)

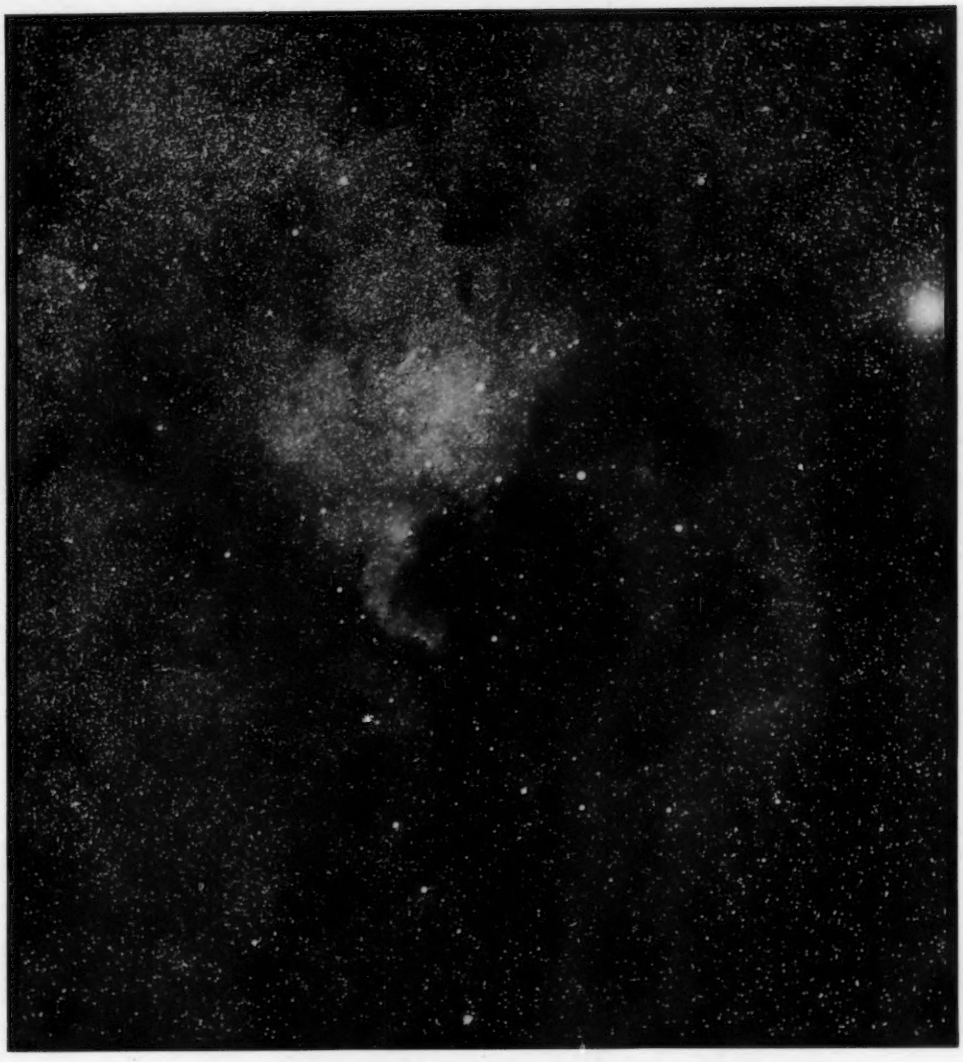
Slide 18.—Vacant lanes running from the nebulous region of Rho Ophiuchi towards the east.

Slide 19.—Great vacant regions about the star Theta Ophiuchi, (See *Popular Astronomy,* No. 140.)

YERKES OBSERVATORY, 1907.

PLATE I

N



North American Nebula
1905 September 4

Photographed with the Brue telescope
Yerkes Observatory

E. E. BARNARD

PLATE II

N

Double Cluster of Perseus
1904 September 15

N

Two Meteor Trails, and Star Cloud in Scutum
1904 April 20

Photographed with the Brue telescope
Yerkes Observatory

E. E. BARNARD

PLATE III

N

Meteor Trail
1899 June 7

N

Brooks' Comet and Meteor
1893 November 13

Photographed at the Yerkes and Lick Observatories

E. E. BARNARD

PLATE IV

N

Nebulous Region of Gamma Cygni
1905 August 28

N

Nebulous Region of Rho Ophiuchi
1905 April 5

Photographed with the Brue telescope
Yerkes Observatory

E. E. BARNARD

PLATE V

N

Giacobinis Comet
1905 December 29

N

Giacobinis Comet
1906 January 5

Photographed with the Brue telescope
Yerkes Observatory

E. E. BARNARD

PLATE VI

N

Earth-lit New Moon
1907 February 14

N

Total Eclipse of the Moon
1906 February 8

Photographed with the Brue telescope
Yerkes Observatory

E. E. BARNARD

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1862	ABBOT, Gen. HENRY L., U.S.A	23 Berkeley St., Cambridge, Mass.
1897	ABBOTT, ALEXANDER C., M.D	University of Pennsylvania, Philadelphia.
1889	ABBOTT, CHARLES CONRAD, M.D	Trenton, N. J.
1886	ADAM, LUCIEN	41 Bard Sevigné, Rennes, France.
1901	ADAMS, CHARLES FRANCIS, LL.D	23 Court St., Boston, Mass.
1900	ADLER, CYRUS, Ph.D	Smithsonian Institution, Washington, D. C.
1875	AGASSIZ, Prof. ALEXANDER	36 Quincy St., Cambridge, Mass.
1876	ÅKERMAN, Prof. RICHARD	Stockholm, Sweden.
1878	ALLEN, Prof. JOEL ASAPH	Am. Museum of Natural History, New York City.
1881	AMES, Rev. CHARLES G	12 Chestnut St., Boston, Mass.
1905	AMES, JOSEPH SWEETMAN, Ph.D	Johns Hopkins University, Baltimore, Md.
1886	ANDERSON, Maj. GEO. L., U.S.A	Ordnance Board, Governor's Island, New York City.
1889	ANGELL, Pres't JAS. BURRILL, LL.D	Ann Arbor, Mich.
1893	APPLETON, Prof. WILLIAM HYDE	Swarthmore, Pa.
1884	ASHHURST, RICHARD L	319 S. 11th St., Philadelphia.
1884	AVEBURY, Right Hon. Sir JOHN LUBBOCK, Lord	High Elms, Down, Kent, Eng.
1877	BACHE, THOMAS HEWSON, M.D	233 S. 13th St., Philadelphia.
1898	BAER, GEORGE F	1718 Spruce St., Philadelphia.
1896	BAILEY, Prof. L. H	Cornell University, Ithaca, N. Y.
1899	BALCH, EDWIN SWIFT	1412 Spruce St., Philadelphia.
1901	BALCH, THOMAS WILLING	1412 Spruce St., Philadelphia.
1897	BALDWIN, Prof. JAMES MARK, D.Sc.	118 W. Franklin St., Baltimore, Md.
1891	BALL, Sir ROBERT STAWELL, LL.D.	Observatory, Cambridge, Eng.
1882	DEBAR, Hon. EDOUARD, SÊVE	Ramsgate, England.
1873	BARKER, Prof. GEORGE F., LL.D	3909 Locust St., Philadelphia.
1884	BARKER, WHARTON	119 S. 4th St., Philadelphia.
1903	BARNARD, EDWARD E., Sc.D	Yerkes Observatory, Williams Bay, Wisconsin.

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1899	BAUGH, DANIEL	1601 Locust St., Philadelphia.
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1902	BECQUEREL, Prof. ANTOINE-HENRI.	6me Dumont d'Urville, Paris, France.
1882	BELL, Prof. ALEXANDER GRAHAM	1331 Connecticut Ave., Washington, D. C.
1895	BEMENT, CLARENCE S.	3907 Spruce St., Philadelphia.
1897	DEBENNEVILLE, JAMES SEGUIN	26 C. Bluff, Yokohama, Japan.
1895	BERTIN, GEORGES	11bis Rue Ballu, Paris, France.
1877	BIDDLE, HON. CRAIG	2033 Pine Street, Phila.
1887	BILLINGS, JOHN S., M.D.	40 Lafayette Place, New York, N. Y.
1889	BLAIR, ANDREW A.	406 Locust St., Philadelphia.
1870	BLAKE, Prof. WM. PHIPPS	Mill Rock, Whitney Ave., New Haven, Conn.
1904	BLOOMFIELD, Prof. MAURICE, LL.D.	861 Park Ave., Baltimore, Md.
1903	BOAS, FRANZ, Ph.D.	123 W. 82d Street, New York, N. Y.
1895	BONAPARTE, PRINCE ROLAND	10 Ave. d'Jena 22, Paris, France.
1904	BOWDITCH, HENRY PICKERING, M.D.	Sunnyside, Jamaica Plain, Boston, Mass.
1840	BOYÈ, Prof. MARTIN H.	Coopersburg, Lehigh Co., Pa.
1877	BRACKETT, Prof. CYRUS FOGG	4 Prospect Ave., Princeton, N. J.
1886	BRANNER, Prof. JOHN C.	Stanford University, Cal.
1902	BRASHEAR, JOHN A., Sc.D.	1954 Perryville Ave., Allegheny, Pa.
1886	BREZINA, Dr. ARISTIDES	XIII[e] St. Veitgasse, 15, Vienna, Austria.
1899	BROEGGER, Prof. W. C.	Christiania, Norway.
1886	BROOKS, Prof. WILLIAM KEITH	Johns Hopkins University, Baltimore, Md.
1901	BROWN, Prof. AMOS P.	20 E. Penn St., Germantown, Philadelphia.
1879	BROWN, ARTHUR ERWIN	1208 Locust St., Philadelphia.
1898	BROWN, Prof. ERNEST WILLIAM	Yale University, New Haven, Conn.
1895	BRUBAKER, ALBERT P., M.D.	105 N. 34th St., Philadelphia.
1865	BRUSH, Prof. GEORGE J.	Yale Univ., New Haven, Conn.
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1895	BRYCE, RIGHT HON. JAMES	54 Portland Place, London, W., England.

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1895	BUDGE, E. A. WALLIS, Litt.D.	British Museum, London, Eng.
1881	BUTLER, HON. WILLIAM	West Chester, Pa.
1899	CADWALADER, JOHN	1519 Locust St., Philadelphia.
1903	CAMPBELL, WM. WALLACE, LL.D.	Lick Observatory, Mt. Hamilton, California.
1885	CANNIZZARO, TOMASO	Santa Maria fuori cinta, Casa Roffa, Messina, Sicily.
1873	CAPELLINI, Prof. GIOVANNI	Rue Medal Hayden, 1896, Bologna, Italy.
1875	CARLL, Prof. JOHN FRANKLIN	Pleasantville, Venango Co., Pa.
1902	CARNEGIE, ANDREW, LL.D.	2 E. 91st St., New York, N. Y.
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1888	CATTELL, Prof. J. MCKEEN	Garrison-on-Hudson, N. Y.
1905	CHAMBERLIN, THOMAS CHROWDER, LL.D.	Univ. of Chicago, Chicago, Ill.
1880	CHANCE, HENRY MARTYN, M.D.	819 Drexel Building, Phila.
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1875	CHAPMAN, HENRY C., M.D.	2047 Walnut St., Phila.
1886	DECHARENCEY, COMTE HYACINTH.	25 Rue Barbet de Jouy, Paris, France.
1904	CHEYNEY, Prof. EDWARD POTTS	259 S. 44th St., Philadelphia.
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1902	CLARK, Prof. WILLIAM BULLOCK.	Johns Hopkins University, Baltimore, Md.
1904	CLARKE FRANK WIGGLESWORTH, Sc.D.	U. S. Geological Survey, Washington, D. C.
1883	CLAYPOLE, Prof. E. W.	Pasadena, Cal.
1895	CLEEMANN, RICHARD A., M.D.	2135 Spruce St., Philadelphia.
1897	CLEVELAND, HON. GROVER	Westland, Princeton, N. J.
1902	COLLITZ, Prof. HERMANN, Ph.D.	Johns Hopkins University, Baltimore, Md.
1897	CONKLIN, Prof. EDWIN GRANT	University of Penn., Phila.
1898	CONVERSE, JOHN H.	500 N. Broad St., Phila.
1895	COOK, Hon. JOEL	849 N. Broad St., Phila.
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1886	CROOKES, SIR WILLIAM	7 Kensington Park Gardens, London, W., England.
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1898	DARWIN, Sir GEORGE HOWARD, K.C.B.	Newnham Grange, Cambridge, England.
1907	DAVENPORT, CHARLES BENEDICT, Ph.D.	Cold Spring Harbor, L. I., N. Y.
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1866	DAVIDSON, Prof. GEORGE	2221 Washington St., San Francisco, Cal.
1899	DAVIS, Prof. WILLIAM MORRIS	Cambridge, Mass.
1880	DAWKINS, Prof. WILLIAM BOYD	Woodhurst, Fallowfield, Manchester, England.
1899	DAY, FRANK MILES	Allen's Lane, Mount Airy, Philadelphia.
1905	DELAGE, Prof. YVES	Université de Paris, Station Zoologique de Roscoff, Paris, France.
1904	DELITZSCH, Prof. FRIEDRICH, Ph.D.	University of Berlin, Berlin, Germany.
1892	DERCUM, FRANCIS X., M.D.	1719 Walnut St., Phila.
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1884	DICKSON, SAMUEL	901 Clinton St., Philadelphia.
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1906	DONALDSON, HENRY HERBERT, Ph.D.	Wistar Institute, 36th St. and Woodland Ave., Phila.
1886	DONNER, Prof. OTTO	Helsingfors, Finland.
1881	DOOLITTLE, Prof. C. L.	Upper Darby, Delaware Co., Pa.
1903	DOOLITTLE ERIC	University of Pennsylvania, Philadelphia.
1899	DOUGHERTY, THOMAS HARVEY	School House Lane, Germantown, Philadelphia.
1877	DOUGLAS, JAMES, LL.D.	Spuytenduyvil, New York, N. Y.
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1867	DUNNING, GEORGE F.	500 Madison Ave., New York, N. Y.
1873	DUPONT, EDOUARD.	Royal Museum, Brussels, Belgium.
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1871	DUTTON, Maj. CLARENCE E., U.S.A.	Englewood, N. J.
1880	ECKFELDT, JACOB B.	U. S. Mint, Philadelphia.
1877	EDDY, Prof. H. TURNER.	University of Minnesota, Minneapolis, Minn.
1896	EDISON, THOMAS ALVA, Ph.D.	Orange, N. J.
1895	EDMUNDS, Hon. GEORGE F.	Aiken, S. C.
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1871	ELIOT, Pres't CHARLES W.	17 Quincy St., Cambridge, Mass.
1895	ELLIOTT, Prof. A. MARSHALL.	Johns Hopkins University, Baltimore, Md.
1897	ELY, THEODORE N.	115 Broad St. Station, Phila.
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1898	EMMET, W. L. R.	48 Washington Ave., Schenectady, N. Y.
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1906	ENGLER, ADOLF, Ph.D.	Botanisch. Garten, Berlin—Dahlem, Germany.
1907	D'ESTOURNELLES DE CONSTANT, Baron	Paris, France.
1881	EVANS, SIR JOHN, K.C.B.	Britwell, Berkhamsted, Herts, England.
1895	EWELL, MARSHALL D., M.D., LL.D.	59 Clark St., Chicago, Ill.
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1895	FENNELL, C. A. M., Litt.D.	139 Chesterton Road, Cambridge, England.
1890	FIELD, ROBERT PATTERSON.	The Normandie, 36th and Chestnut Sts., Philadelphia.
1897	FINE, Prof. HENRY B.	Princeton, N. J.
1897	FISHER, SYDNEY GEORGE, LL.D.	328 Chestnut St., Phila.
1901	FLEXNER, SIMON, M.D.	Rockefeller Institute, 50th and Lexington Ave., New York, N. Y.
1880	FLINT, AUSTIN, M.D.	118 E. 19th St., New York, N. Y.

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1891	FORBES, Prof. GEORGE, F.R.S.	34 Great George St., S. W., London, England.
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1880	FRALEY, JOSEPH C.	1833 Pine St., Philadelphia.
1904	FRANCKE, Prof. KUNO, Ph.D.	Harvard University, Cambridge, Mass.
1872	FRAZER, PERSIFOR, Dr.	928 Spruce St., Philadelphia.
1905	FRAZIER, CHARLES HARRISON, M.D.	1724 Spruce St., Philadelphia.
1889	FRIEBIS, GEORGE, M D.	1906 Chestnut St., Phila.
1890	FULLERTON, Rev. GEORGE S.	Columbia University, New York, N. Y
1873	FULTON, Hon. JOHN	136 Park Pl., Johnstown, Pa.
1880	FURNESS, HORACE HOWARD, LL.D.	Wallingford, Del. Co., Pa.
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1897	FURNESS, WILLIAM H., 3d, M.D.	The Warwick, 1906 Sansom St., Philadelphia.
1886	GATES, MERRILL E., LL.D.	1315 New Hampshire Ave., Washington, D. C.
1880	GEIKIE, SIR ARCHIBALD.	Shepherd's Down, Haslemere, Sussex, England.
1876	GEIKIE, Prof. JAMES.	83 Colinton Rd. Edinburgh, Scotland.
1886	GENTH, Prof. F. A., JR.	222 Walnut St., Phila.
1854	GIBBS, Prof. OLIVER WOLCOTT.	158 Gibbs Ave., Newport, R. I.
1901	GIGLIOLI, Prof. HENRY H.	19 Via Romanæ, Florence, Italy.
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1903	GILDERSLEEVE, Prof. BASIL L., LL.D.	1002 Belvidere Terrace, Baltimore, Md.
1867	GILL, THEODORE N., M.D., Ph.D.	Smithsonian Institution, Washington, D. C.
1876	GILMAN, DANIEL C., LL.D.	614 Park Ave., Baltimore, Md.
1895	GLAZEBROOK, RICHARD T., F.R.S.	Bushey House, Teddington, Middlesex, Eng.
1907	GOOCH, FRANK AUSTIN, Ph.D.	New Haven, Conn.
1893	GOODALE, Prof. GEORGE LINCOLN.	5 Berkeley St., Cambridge, Mass.
1896	GOODSPEED, Prof. ARTHUR W.	Univ. of Pennsylvania, Phila.
1892	GOODWIN, HAROLD.	133 S. 12th St., Philadelphia.
1895	GOODWIN, Prof. W. W.	Cambridge, Mass.
1900	GRAY, GEORGE, Hon.	Wilmington, Del.
1904	GREELY, GEN. ADOLPHUS W., U.S.A.	1914 G St., Washington, D. C.
1893	GREEN, SAMUEL A., M.D.	Massachusetts Historical Soc., Boston, Mass.
1879	GREENE, WILLIAM H., M.D.	N. E. Cor. Arch and 16th Sts., Philadelphia.

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1899	GREENMAN, MILTON J., M.D.	Wistar Institute, 36th St. and Woodland Ave., Phila.
1888	DÈ GREGORIO, MARQUIS ANTONIO	Al Molo, Palermo, Sicily.
1891	GREGORY, Prof. CASPAR RENÉ	Naunhoferstrasse 5 Marienhöhe, Leipzig-Stötteritz, Germany.
1907	GRIFFITH, J. P. CROZER, M.D.	1810 Spruce St., Philadelphia.
1886	DE GUBERNATIS, Prof. ANGELO	Florence, Italy.
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1902	HADLEY, Pres't ARTHUR T.	Yale University, New Haven, Conn.
1885	HAECKEL, Prof. Dr. ERNST	University, Jena, Germany.
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1870	HALE, REV. EDWARD EVERETT	39 Highland St., Roxbury, Mass.
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1875	HALL, CHARLES EDWARD	Instituto Geologico de Mexico, Santa Maria, Mexico, Mex.
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1891	HAMY, Dr. ERNST T.	36, Rue Geoffroy-St-Hilaire, Pavillon de Buffon, Paris, France.
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1877	HART, Prof. JAMES MORGAN	1 Reservoir Ave., Ithaca, N. Y.
1906	HASTINGS, Prof. CHARLES S., Ph.D.	248 Bradley St., New Haven, Conn.
1878	HAUPT, Prof. LEWIS M.	107 N. 35th St., Philadelphia.
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1886	HAYS, I. MINIS, M.D.	266 S. 21st St., Philadelphia.
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1895	HEYSE, PAUL, Ph.D.	Munich, Bavaria.
1903	HILL, GEORGE WILLIAM, LL.D.	West Nyack, N. Y.
1906	HILLEBRAND, WILLIAM FRANCIS, Ph.D.	506 T St., N. W., Washington, D. C.
1897	HILLER, H. M., M.D.	Kohoka, Mo.

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1886	HILPRECHT, Prof. HERMANN V., Ph.D.	Free Museum of Art, Univ. of Penn., Phila.
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1899	HIRST, BARTON COOKE, M.D.	1821 Spruce St., Philadelphia.
1870	HITCHCOCK, Prof. CHAS. HENRY.	Dartmouth College. Hanover, N. H.
1897	HOLDEN, Prof. EDWARD S.	U. S. Military Academy, West Point, N. Y.
1886	HOLLAND, JAMES W., M.D.	2006 Chestnut St., Phila.
1899	HOLMES, Prof. WILLIAM H.	Bureau of Ethnology, Smithsonian Institution, Washington, D. C.
1869	HOOKER, SIR JOSEPH DALTON, G.C.S.I.	The Camp, Sunningdale, Eng.
1886	HORNER, INMAN.	1811 Walnut St., Phila.
1872	HOUGH, Prof. GEORGE W.	Northwestern University, Evanston, Ill.
1872	HOUSTON, Prof. EDWIN J.	4619 Chester Ave., Phila.
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1903	HOWELL, Prof. WILLIAM HENRY.	232 W. Lanvale St., Baltimore, Md.
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1877	HUMPHREY, H. C.	The New York Glucose Co., Edgewater, Bergen Co., N. J.
1895	HUNTER, RICHARD S.	1413 Locust St., Phila.
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1875	INGHAM, WM. ARMSTRONG.	320 Walnut St., Phila.
1893	D'INVILLIERS, EDWARD VINCENT.	506 Walnut St., Phila.
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1897	JASTROW, Prof. MORRIS, JR.	248 S. 23d St., Philadelphia.
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1885	JAYNE, HORACE, M.D.	318 S. 19th St., Philadelphia.
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1905	JORDAN, Pres't DAVID STARR.	Stanford Univ., Cal.
1884	JORDAN, FRANCIS, JR.	111 N. Front St., Phila.
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1883	KANE, ELISHA KENT.	Kushequa, Pa.
1907	KAPTEYN, Prof. JOHN C.	Groningen, Holland.
1897	KARPINSKY, Prof. ALEX. PETROVITCH	Geological Survey, St. Petersburg, Russia..

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1899	KEASBEY, Prof. LINDLEY M., Ph.D.	1802 Colorado St., Austin, Texas.
1897	KEEN, GREGORY B.	3237 Chestnut St., Phila.
1884	KEEN, WILLIAM W., M.D., LL.D.	1729 Chestnut St., Phila.
1898	KEISER, Prof. EDWARD H., Ph.D.	Washington University, St. Louis, Mo.
1900	KELLER, Prof. HARRY F.	Central High School, Phila.
1896	KENNELLY, A. E., D.Sc.	Harvard University, Cambridge, Mass.
1905	KITTREDGE, GEORGE LYMAN, LL.D.	8 Hilliard St., Cambridge, Mass.
1898	KNIGHT, Prof. WILLIAM A.	Malvern, England.
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1899	LEARNED, Prof. MARION D.	University of Penna., Phila.
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1899	LOEB, Dr. JACQUES	University of California, Berkeley, Cal.
1878	LONGSTRETH, MORRIS, M.D.	1416 Spruce St., Phila.
1906	LORENTZ, Dr. HENDRIK ANTON	University of Leyden, Leyden, Holland.
1904	LOVETT, Prof. EDGAR ODELL, LL.D.	Princeton, N. J.
1892	LOW, HON. SETH	30 E. 46th St., New York, N. Y.
1897	LOWELL, PERCIVAL	53 State St., Boston, Mass.
1869	LYMAN, BENJAMIN SMITH	708 Locust St., Phila.
1897	MABERY, Prof. CHARLES F.	57 Adelbert St., Cleveland, O.
1886	MACALISTER, Pres't JAMES	4031 Walnut St., Phila.
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1896	MCCOOK, Rev. HENRY C., D.D.	Devon, Pa.
1879	MCCREATH, ANDREW S.	121 Market St., Harrisburg, Pa.
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1899	MACKENZIE, Prof. ARTHUR S., Ph.D.	Dalhousie University, Halifax, Nova Scotia.
1907	MCMURRICH, Prof. JAMES PLAYFAIR	University of Toronto, Toronto, Canada.
1896	MAGIE, Prof. WM. FRANCIS, Ph.D.	Princeton, N. J.
1897	MAHAN, Capt. ALFRED T., U.S.N.	160 W. 86th St., New York.
1906	MALL, FRANKLIN PAINE, M.D., LL.D.	1514 Bolton St., Baltimore, Md.
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1878	MARCH, Prof. FRANCIS ANDREW	Lafayette College, Easton, Pa.
1901	MARCONI, GUGLIELMO	18 Finch Lane, E. C., London, England.
1907	MARK, Prof. EDWARD LAURENS, LL.D.	109 Irving St., Cambridge, Mass.
1878	MARKS, Prof. WILLIAM D.	218 The Bourse, Philadelphia.

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1890	MASCART, Prof. E.	16 Rue Christophe Colomb. Paris, France.
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1899	MASON, Prof. OTIS T.	U. S. National Museum, Washington, D. C.
1896	MASON, Prof. WM. PITT, M.D.	Rensselaer Polytechnic Institute, Troy, N. Y.
1891	MASPERO, Prof. GASTON-CAMILLE.	Collège de France, Paris, France.
1899	MATTHEWS, ALBERT.	483 Beacon St., Boston, Mass.
1899	MEIGS, ARTHUR V., M.D.	1322 Walnut St., Phila.
1901	MEIGS, WILLIAM M.	1815 Pine St., Phila.
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1897	MELVILLE, Rear Admiral GEO. W., U. S. N.	615 Walnut St., Philadelphia.
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1881	MURRAY, JAMES A. H., LL.D.	Sunnyside, Banbury Road, Oxford, England.
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1866	NIKITIN, Prof. SERGI.	Geological Survey, St. Petersburg, Russia.
1907	NIPHER, Prof. FRANCIS EUGENE.	1220 Hamilton Ave., St. Louis, Mo.
1906	NÖLDEKE, Prof. THEODOR, Ph.D.	University of Strassburg, Strassburg, Germany.
1905	NORDENSKJÖLD, Prof. OTTO.	Goteborg 3, Sweden.
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1887	OSBORN, Prof. HENRY F., LL.D.	American Museum of Natural History, New York, N. Y.
1885	OSLER, Prof. WILLIAM, M.D.	13 Norham Gardens, Oxford, Eng.
1898	PANCOAST, HENRY S.	78 Vernon St., Hartford, Conn.
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1899	PAUL, J. RODMAN	903 Pine St., Philadelphia.
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1863	PENROSE, R. A. F., M.D.	1331 Spruce St., Phila.
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1897	PEPPER, GEORGE WHARTON, LL.D.	701 Drexel Building, Phila.
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1886	POSTGATE, Prof. JOHN P.	Cambridge, England.
1899	PREECE, SIR WM. HENRY, K.C.B., F.R.S.	13 Queen Anne's Gate, London, S. W., England.
1875	PRIME, FREDERICK	1008 Spruce St., Phila.
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1899	RAMSAY, SIR WILLIAM, K.C.B., F.R.S.	University College, Gower St., W. C. London, Eng.
1901	RAVENEL, MAZŸCK P., M.D.	University of Wisconsin, Madison, Wis.
1898	RAWLE, FRANCIS	328 Chestnut St., Phila.
1899	RAWLE, WILLIAM BROOKE	230 S. 22d St., Phila.

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1898	REDWOOD, Sir BOVERTON, F.R.S.	4, Bishopsgate St. Within, E. C., London, England.
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1862	RÖHRIG, Prof. F. L. OTTO	402 S. Oakland Ave., Pasadena, Cal.
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1891	ROSENGARTEN, JOSEPH G., LL.D.	1704 Walnut St., Phila.
1882	DE ROSNY, Prof. LÉON	28 Rue Mazarin, Paris, France.
1877	ROTHROCK, JOSEPH T., M.D.	West Chester, Pa.
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1894	SACHSE, JULIUS F., Litt.D.	4428 Pine St., Phila.
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1897	SANDERS, RICHARD H.	1225 Locust St., Phila.
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1873	SCLATER, PHILIP LUTLEY, Ph.D., F.R.S.	3 Hanover Square, London, W., England.

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1878	SCUDDER, SAMUEL HUBBARD.	Cambridge, Mass.
1897	SEE, THOMAS J. J., LL.D.	Observatory, Mare Island, Cal.
1899	SELLERS, COLEMAN, Jr.	410 N. 33d St., Phila.
1885	SERGI, Prof. GIUSEPPE.	Università Romana, Rome, Italy.
1886	SHARP, BENJAMIN, M.D.	Academy of Natural Sciences, Philadelphia.
1882	SHARPLES, Prof. STEPHEN PASCHALL.	26 Broad St., Boston, Mass.
1875	SHERWOOD, ANDREW.	Montavilla, Portland, Oregon.
1899	SIGSBEE, Admiral CHARLES D., U.S.N.	Navy Dept., Washington, D. C.
1900	SINKLER, WHARTON, M.D.	1606 Walnut St., Phila.
1897	SMITH, A. DONALDSON, M.D.	1811 Walnut St., Phila.
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1887	SMITH, Prof. EDGAR F.	Univ. of Pennsylvania, Phila.
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1894	SNELLEN, HERMAN, Jr., Ph.D.	Utrecht, Netherlands.
1873	SNOWDEN, A. LOUDON, LL.D.	1812 Spruce St., Phila.
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1873	SPOFFORD, A. R., LL.D.	Library of Congress, Washington, D. C.
1903	STENGEL, ALFRED, M.D.	1811 Spruce St., Phila.
1897	STEPHENS, Prof. H. MORSE.	University of California, Berkeley, Cal.
1884	STEVENS, Prof. WALTER LECONTE.	Lexington, Va.
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1895	STEVENSON, SARA Y., Sc.D.	237 S. 21st St., Philadelphia.
1898	STILLWELL, LEWIS B.	Sixth St., Lakewood, N. J.
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1886	SUESS, Prof. EDOUARD.	K. K. Geologische Reichsanstalt, Vienna, Austria.
1895	SULZBERGER, Hon. MAYER.	1303 Girard Ave., Phila.
1886	SZOMBATHY, Prof. JOSEF.	Burgring 7, Vienna, Austria.
1897	TATHAM, WILLIAM.	1811 Walnut St., Phila.
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1902	THOMPSON, Prof. SILVANUS P., F.R.S.	Technical College, Finsbury, Leonard St., City Road, London, E. C., England.
1876	THOMSON, Prof. ELIHU	22 Monument Ave., Swampscott, Mass.
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1885	IM THURN, EVERARD F.	Govt. House, Sura, Fiji, Western Pacific.
1902	TILGHMAN, BENJAMIN CHEW	1126 S. 11th St., Phila.
1906	TITCHENER, Prof. EDWARD BRADFORD, Ph.D.	Cornell Heights, Ithaca, N. Y.
1906	TITTMANN, OTTO HILGARD	2014 Hillyer Place, Washington, D. C.
1886	TOPINARD, Prof. Dr. PAUL	105 Rue de Rennes, Paris, France.
1895	TOWER, Hon. CHARLEMAGNE, JR., LL.D.	American Embassy, Berlin, Germany.
1903	TRELEASE, WILLIAM, Sc.D.	Missouri Botanical Garden, St. Louis, Mo.
1899	TREVELYAN, Rt. Hon. Sir GEORGE OTTO	8 Grosvenor Crescent, S. W. London, England.
1896	TROWBRIDGE, Prof. JOHN	Harvard University, Cambridge, Mass.
1899	TRUE, Dr. FREDERICK WILLIAM	U. S. National Museum, Washington, D. C.
1882	TSCHERMAK, GUSTAV	Universität, Vienna, Austria.
1897	TSCHERNYSCHEW, Prof. THEODORE	Geological Survey, St. Petersburg, Russia.
1907	TURNER, SIR WILLIAM, K.C.B., F.R.S.	6 Eton Terrace, Edinburgh, Scotland.
1890	TURRETTINI, Prof. THEODORE	Geneva, Switzerland.
1889	TUTTLE, DAVID K., Ph.D.	U. S. Mint, Philadelphia.
1889	TYLER, Hon. LYON G., Pres't	Williamsburg, Va.
1887	TYSON, JAMES, M.D.	1506 Spruce St., Phila.
1890	UNWIN, Prof. WILLIAM C.	7 Palace Gate Mansions, London, England.
1904	VAN'T HOFF, Prof. JAKOB H.	Univ. of Berlin, Berlin, Ger.

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1905	VENABLE, Pres't FRANCIS P., LL.D.	Chapel Hill, N. C.
1870	VOSE, Prof. GEORGE L.	Brunswick, Maine.
1903	DE VRIES, Prof. HUGO	University of Amsterdam, Amsterdam, Netherlands.
1885	WAGNER, SAMUEL	Greenbank Farm, West Chester, Pa.
1874	WAHL, WILLIAM H., Ph.D.	15 S. 7th St., Philadelphia.
1897	WALCOTT, CHARLES D., LL.D.	Smithsonian Institution, Washington, D. C.
1904	WALDEYER, Prof. WILHELM	56 Luisenstrasse, Berlin, N. W., 6, Germany.
1873	WALLACE, ALFRED RUSSEL, LL.D.	Broadstone, Wimborne, Eng.
1889	WARD, LESTER F., LL.D.	Brown University, Providence, R. I.
1881	WARE, LEWIS S.	54 Rue de la Bienfaisance, Paris, France.
1897	WARFIELD, Pres't ETHELBERT D.	Easton, Pa.
1906	WEBSTER, ARTHUR GORDON, Ph.D.	66 West St., Worcester, Mass.
1906	WEISMANN, Prof. AUGUST	Stadt Strasse 4, Freiburg (I. Br.), Baden, Germany.
1896	WELCH, Prof. WILLIAM H., M.D.	807 St. Paul St., Baltimore, Md.
1869	WHARTON, JOSEPH	P. O. Box 1332, Phila.
1869	WHITE, Hon. ANDREW D.	White Library, Cornell Univ., Ithaca, N. Y.
1878	WHITE, Prof. ISRAEL C.	119 Wiley St., Morgantown, W. Va.
1905	WHITFIELD, J. EDWARD	406 Locust St., Phila.
1898	WHITFIELD, Prof. R. P.	American Museum of Natural History, New York, N. Y.
1899	WHITMAN, Prof. CHARLES OTIS, Ph.D., LL.D.	Univ. of Chicago, Chicago, Ill.
1878	WILDER, Prof. BURT G.	McGraw Hall, Ithaca, N. Y.
1904	WILEY, HARVEY W., M.D., LL.D.	U. S. Dept. of Agriculture, Washington, D. C.
1895	WILLCOX, JOSEPH	"The Clinton," 10th and Clinton Sts., Philadelphia.
1897	WILLIAMS, Prof. EDWARD H., JR.	53 Phillips St., Andover, Mass.
1888	WILLIAMS, TALCOTT, LL.D.	916 Pine St., Phila.
1905	WILLIS, BAILEY	U. S. Geological Survey, Washington, D. C.
1890	WILLIS, Prof. HENRY	4036 Baring St., Phila.
1885	WILSON, JAMES CORNELIUS, M.D.	1511 Walnut St., Phila.
1887	WILSON, Prof. WILLIAM POWELL, M.D.	Commercial Museum, Phila.

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1879	WOOD, RICHARD	1620 Locust St., Phila.
1899	WOOD, STUART	1620 Locust St., Phila.
1874	WOODWARD, HENRY, LL.D., F.R.S.	13 Arundel Gardens, Notting Hill, London, W., Eng.
1902	WOODWARD, Pres't ROBERT S., Ph.D.	Carnegie Institution, Washington, D. C.
1896	WRIGHT, Prof. ARTHUR W., Ph.D.	73 York Square, New Haven, Conn.
1900	WRIGHT, WILLIAM ALDIS, LL.D., D.C.L.	Trinity Coll., Cambridge, Eng.
1895	WUNDT, Prof. WILLIAM	Leipzig, Germany.
1899	WURTS, ALEXANDER JAY	Carnegie Technical School, Pittsburg, Pa.
1886	WYCKOFF, Lieut. A. B., U.S.N.	Navy Dep't, Washington, D. C.

BIOGRAPHICAL NOTICE OF ALBERT HENRY SMYTH.

By JOSEPH G. ROSENGARTEN.

(*Read May 17, 1907.*)

Albert Henry Smyth was elected a member of the American Philosophical Society on May 20, 1887. He has been continuously active and useful in it. At the request of the President this brief statement of Professor Smyth's life and work is presented in accordance with our custom.

He was born in Philadelphia on June 18, 1863, and was educated at the George G. Meade Public School, graduated in the June '82 class of the Philadelphia High School, was the valedictorian, and encouraged by the then President Dr. Riche and Professor Taylor, later President, went to Johns Hopkins University, Baltimore, where he received a Master of Arts degree "causa honoris," in 1886,—it was his thesis for his M.A. degree, "Shakespeare's Pericles and Apollonius of Tyre," that rewritten and with large additions, he read before this Society. It is printed in our *Proceedings,* and earned praise for its research on a recondite subject.

His services to this Society were constant and valuable,—he was one of its curators, a member of the Library Committee, represented it at the University of Glasgow on its forty-fifth anniversary, and at the dedication in Paris of the Statue of Franklin, the gift of John H. Harjes, a former resident of this city,—on that occasion too by the appointment of the President of the United States, he was the representative of this country, and his address received the well deserved praise of all his auditors and readers, among them many of the foremost representatives of French eloquence and learning. His addresses at the annual celebration of this Society were always noteworthy, and his last appearance at the general meeting in April of this year, shortly before his untimely death, was warmly welcomed.

His printed works include a sketch of "American Literature,"

published in 1888; "Philadelphia Magazines and Their Contributors," 1892; "Bayard Taylor" in "American Men of Letters" series, 1896; "Shakespeare's Pericles and Apollonius of Tyre," 1898. He was the founder and editor of "Shakesperiana," and was thoroughly imbued with knowledge and love of the great dramatist; he edited "Burke's Letter to a Noble Lord," 1898, and "Pope's Homer's Iliad," 1899, and he was a frequent contributor to magazines and newspapers. His papers were like his popular lectures, for some years, notably about Shakespeare's country, with which he was intimate from frequent pilgrimages, often in the companionship of English men of letters whose friendship and sympathy he enjoyed to a degree rare indeed for a man of his age,—he was as much at home among scholars abroad as at home.

His greatest service to this Society, to the public, and to the fame of our founder, was his ten volume edition of the "Works and Correspondence of Benjamin Franklin," only recently completed. It was a great task and it was carried through with characteristic industry, devotion and critical ability. He was largely inspired to this undertaking by his familiarity with the unrivalled collection of Franklin Papers, over seventy folio volumes, long in the possession of this Society. He atoned for the careless editing of Franklin's Works by Wm. Temple Franklin,—he corrected the errors and restored the real words of Franklin, so frequently altered in Sparks' edition, and he made large and valuable additions to Bigelow's, and that venerable and learned master of Franklin literature generously and heartily commended his young successor's work.

Professor Smyth had in contemplation at the time of his too early death, a popular Life of Franklin, and a Life of Washington, and historical students may well regret that his life was not spared for the accomplishment of these tasks.

Elected in 1886 Professor of English Language and Literature in the Central High School of Philadelphia, he showed remarkable gifts for his task, and won the affection and admiration alike of his colleagues and his pupils. He was constantly helping the students who showed ability, and encouraged them in securing admission to Colleges and Universities, or positions, where many of them gained marked distinction. His popularity with the large body of stu-

dents of the High School was an unusual tribute to his ability, his industry and his broad and generous sympathy with all who shared his love of study.

His "Shakespeare's Pericles and Apollonius of Tyre," a study in Comparative Literature, was the outcome of his Johns Hopkins thesis for his M.A. degree,—recast and expanded, it was read before the American Philosophical Society and was printed in volume thirty-seven of its Proceedings. Reprinted in 1898, it obtained great praise from competent Shakespearean critics at home and abroad, and it is a monument of his learning and critical ability. As he said in reply to some verbal criticism of his frequent use of Shakespearean words and phrases, "A student's nature is soon subdued to what it works in, like the dyer's hand, and I have worked in Shakespeare, steeping myself in his language, until unconsciously I use words and phrases which are, to me, rich in suggestion and association," and he made good use of his mastery of Shakespere.

His great work was his "Writings of Franklin." It was the most effective and important tribute to Franklin's Bicentenary, so well celebrated by this and kindred societies, founded by Franklin and of which he was a member. The ten volumes of Franklin will be a lasting monument of Professor Smyth's industry, research and critical acumen. He unearthed new material at home and abroad to the extent of three hundred and eighty-five letters and forty papers all from Franklin's pen, and not printed by any previous editor; he corrected more than two thousand errors in earlier editions, and restored the text so much altered by Sparks in his mistaken notion of improving Franklin's racy and vigorous English. He found new material in public and private collections, in that recently acquired by the Library of the University of Pennsylvania, as a tribute to its great founder, and in public archives at home and abroad, and in the collections never before consulted by any editor of Franklin's writings. He gave a full account of the Franklin Papers, rescued from neglect and now reverently preserved in the Library of the American Philosophical Society, in the Congressional Library, and in that of the University of Pennsylvania. He gave a bibliography of the printed editions of Franklin's Writings, an analysis of his works, philosophical, politi-

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cal and economical, of his satires and bagatelles and of his multifarious correspondence. With all his zeal and admiration for Franklin, and his ability in so many directions, scientific, economic, political, diplomatic, financial and social, Professor Smyth put a proper limit and restriction upon the reproduction of some of Franklin's writings, as unfitted for the public of today, and of some public papers wrongly attributed to Franklin or that have lost their value and interest. What he gives shows Franklin at his best, and justifies that admiration of him as a man and a philosopher, as a statesman and a diplomatist, which has made Franklin's fame world wide.

Smyth's Franklin is a work of great and lasting value, it is the definitive edition of his writings, for the editor gave to it the best results of modern literary canons as to the right way to edit the writings of so marked and individual a man as Franklin. In these days of sound historical methods, and in absolute adhesion to the fixed rule to give the words of the original text of letters and other writings, Professor Smyth edited Franklin's Writings, with a fidelity that commends his edition to all students. The Index, that trying test for all editors, is so complete and exhaustive that an inquirer can easily find every item of Franklin's multifarious writings under subject, place, correspondent or other proper heading. Professor Smyth unburied the earliest of Franklin's writings, the newspaper articles which first revealed his remarkable ability, followed his many notable publications, illuminated his widely scattered correspondence by judicious notes, compressing in many of them in a few lines, the result of many and far reaching investigations. He showed critical care alike in exclusion, inclusion and explanation.

His "Life of Franklin" was all too short, and he had planned to use his large knowledge in the preparation of a Life of Franklin, free from the restraint of space prescribed by the publishers of his "Franklin's Writings," and in it he would have used that intimate knowledge of Franklin which he showed in frequent addresses, in some magazine articles, and in lectures, and particularly in his masterly and eloquent oration on the unveiling of the statue of Franklin in Paris, the work of a Philadelphia artist, Boyle, the

gift of an old resident of Philadelphia, Mr. John H. Harjes,—on April 27, 1906, in the Trocadero. In the presence of a great audience, Professor Smyth added to his reputation by an oration on Franklin that won the plaudits of the foremost French men gathered together to honor Franklin's memory. That he was chosen by President Roosevelt to make the address of presentation of the Franklin statue, was another tribute to his successful work as the editor of "Franklin's Writings," and brought home to French statesmen and men of letters, the wisdom of the choice made by President Roosevelt, himself an historian well qualified to select the best man.

Professor Smyth had a legion of admirers abroad,—he made almost annual pilgrimages to great historical shrines, and had hosts of friends among the foremost men of letters in Great Britain, in Germany and in France,—he had found sympathetic fellow students in Russia and Poland, in Greece and Italy. He knew Stratford on Avon as he knew Shakespeare, thoroughly, and in London literary clubs, in the great Libraries of London and the English Universities, in Paris and Berlin, he was a familiar visitor, known as a sound student, and welcomed for his many and varied gifts; alike in speech and familiar letters he showed his mastery of English literature, and in his many lectures, his wonderful memory was always helpful to his great gift of eloquence.

As a lecturer in University Extension and Free Library courses and on other occasions, he was heard by thousands, and always with delight and instruction. Under the pressure of the hard work on his ten volume Franklin, he was obliged to curtail his lectures, but in the few given by him during the last winter, he seemed to find relaxation from his Franklin and from his High School work, in delightful lectures on the literature and the literary men and shrines with which he was so familiar. Gifted with a fine presence and an admirable voice, his lectures were a source of infinite pleasure and of much solid instruction.

He gave to the Philosophical Society two capital memorial addresses, one on Dr. Daniel G. Brinton, the other on Henry Phillips, Jr., both scholars and men who had given much of their best work to this Society, and Professor Smyth's tributes were well worthy

of the subjects. His many avocations were always so arranged as to allow him to be a frequent attendant at the meetings of the Society and its committees; his share in its annual meetings was an active one, and all who heard his brief, incisive, witty and well turned addresses in introducing the speakers at its last Annual Dinner, felt that the death of such a man at the age of forty-three, was indeed a great loss and a lasting sorrow.

That such a man as Albert Smyth, with his vigor and outspoken courage, should have enemies was natural, and to their discredit rather than to his, for he outlived the attacks made upon him, and showed that there was little or no foundation for them, by the amount and excellence of his work, by the appreciation of his colleagues and pupils at the High School, and by the admiration of all who were associated with him in his many fields of activity. Life seemed just bringing him the best fruits of his laborious youth,—he was asked by Publishers to undertake more literary work, and with each year this became easier to him, for his large store of learning was always at his call. One of our great Universities was about to call him to succeed a well recognized leader in history and literature, another was about to confer on him a degree of LL.D., and it was thought that he might well have the offer as one of the professorial American representatives in a great German University. His only doubt was as to giving up teaching and lecturing to enable him to devote himself to authorship,—but the end came suddenly, and now we have only his literary remains, and the recollection of a personality that attracted all who came within its reach. Wit, eloquence, learning, many unusual gifts concentrated in him.

His early youth up to manhood was one of much hardship and struggle, but he was never embittered by his hard experience of poverty, nor was he spoiled by the success of his mature years and the praise that came with it. He never forgot any kindness or help shown to him in his hours of trial,—and he was always watchful and helpful of the young men who came under his observation,—to them he repaid in abundant measure, all and much more than all of the help that had benefited him. This was the truest test and proof of the sound manliness of his character, and this it

was, quite as much as admiration for his gifts and talents and the good use he made of them, that made him hosts of friends and endeared him to them.

Mr. John Bigelow, the leading authority on Franklin and the man who rescued the original MS. of the famous Autobiography from oblivion, wrote of Professor Smyth's Franklin, "The development of the scientific side of Franklin will be new to the general reader, and the lack of it was perhaps the most conspicuous deficiency of all previous collections," and again on the completion of the work, "Your collection of the literary remains of Franklin constitutes in my judgment one of the most faithful, conscientious and thorough pieces of editorial work with which our literature has been enriched. It places the crown of glory upon the fame of Franklin which no one will ever dare or desire to displace." Such praise from such a man as John Bigelow, himself the foremost exponent of Franklin literature, was indeed grateful.

Of all the many and touching obituary notices of Professor Smyth, the most eloquent was that of William Winter, in the New York Tribune of May fifth, the day after Professor Smyth's death. Winter himself is a Shakespearian scholar, a poet and a man of letters,—he had great sympathy with his younger brother in literature, and it is admirably shown in his biographical and critical sketch. I am sure it will be welcomed by all who knew Professor Smyth and admired his gifts.

"Albert Henry Smyth.[1]

"One of the noblest minds, one of the gentlest spirits, one of the most auspicious lives in American literature, passes from this world, in the death of Albert Henry Smyth, which befell yesterday morning in Philadelphia. To those who intimately knew him the news of this sudden bereavement brings with it a shock so dreadful as almost to paralyze thought and make any sort of commemorative word impossible. He was in the prime of life: he was in the affluence of enjoyment and hope: he had just completed and published his superb edition of the works of Franklin, together with his Life of that statesman: the echoes of his oratorical triumph at Paris, where he spoke, at the international unveiling of the statue of the great philosopher, had not died away: he had gained an un-

[1] New York *Daily Tribune*, Sunday, May 5, 1907. 2nd Edition.

fading laurel of fame: he was surrounded with affectionate friends: he was richly honored: he was dearly loved: and the pathway to yet more splendid achievements in letters and a yet wider circle and ampler wealth of friends and of honors seemed opening before him, in one long vista of golden promise. His vitality, alike of body and mind, was so extraordinary that no thought of death could ever be associated with him. He seemed formed to lead battalions of thought and to endure forever. His countenance was the beacon light of hope and joy. He animated every mind with which he came in contact. He dissipated all doubts of a glorious future, and he dispelled all dejection. He was a ripe and thorough scholar, and he used his scholarship to cheer the onward march, and not to dispense gloom. He was a natural orator. He possessed a wonderful memory, and it was richly stored with knowledge of the classic literature of all lands. It is doubtful whether, in this respect, his equal exists among American men of letters. He was a reverent student of Shakespeare, and he was entirely competent as a Shakespeare scholar. Among his works there is a most admirable book on "Pericles and Apollonius." He wrote a life of "Bayard Taylor" and a charming book upon the magazines of Philadelphia and the literary movement in that old city—which he so much loved and in which he will be so deeply mourned and so tenderly remembered. His ambition was to excel in learning and to augment the excellence of American literature. He always advocated the right. He abhorred and denounced all the "crank" movements of the day, and all the efforts now in progress to corrupt the pure stream of literature with erotic mush. In one word, he was all that is meant by gentleman. Our society can ill afford to lose such a man as Albert Henry Smyth. Intellectual men find the strife of this world very hard, advocating that which is right, but the best that any thinking worker can do is to follow in his footsteps. The loss of him is unspeakable—but his example remains.

"W. W."

SOME OF THE SUBJECTS OF PROFESSOR SMYTH'S LECTURES.

As characteristic of the width and breadth of his studies, the following list will show how far reaching were his lectures, the fruit of much reading and study.

Franklin; Pepys; Thos. Love Peacock; Modern Polish Literature; Modern Symbolists; American Literature; English Literature; Shakespeare; Shakespeare Readings; Burns and Scott; The Lake School and Country; Nineteenth Century Authors; Literary Memorials of Philadelphia; Irving and Cooper; Hawthorne and Poe; Whittier; The Argonauts of '49; Lowell; The Land of Shakespeare; Shakespeare as a Dramatic Artist, illustrated by an exposition of the construction of the Merchant of Venice and Midsummer Night's Dream, Hamlet, Macbeth and King Lear.

American Literature:—The Colonial Period; The Revolutionary Period; Washington Irving and the New York Writers; Emerson and the awakening of New England; Hawthorne and Poe; Lowell and American Culture; Burns, Scott and the Lake Poets; Bayard Taylor; The Land of Burns and Scott; Wordsworth; Coleridge; Southey, Wilson and De Quincey, Harriet Martineau, the Arnolds, Ruskin and Wm. Watson.

English Literature from Shakespeare to Tennyson; Byron, Shelley, Tennyson, Meredith, Hardy, Kipling.

This is but part of the lecture courses given by Professor Smyth from 1890 to 1907, and not only in Philadelphia and its neighborhood, but in many distant localities.

BIBLIOGRAPHY OF ALBERT HENRY SMYTH.

Bayard Taylor. (American men of letters.) 1896.

Philadelphia Magazines and Their Contributors. 1892.

Shakespeare's Pericles and Apollonius of Tyre, a Study in Comparative Literature. 1898.

Syllabus of a Course of Six Lectures on American Literature. (American Society for the Extension of University Teaching.) University extension lectures, syllabi. 1890–96. Ser. A.

Syllabus of a Course of Six Lectures on Bayard Taylor and his Friends. (American Society for the Extension of University Teaching.) University extension lectures syllabi. 1890–96. Ser. D.

Syllabus of a Course of Six Lectures on English Literature. (American Society for the Extension of University Teaching.) University extension lectures, syllabi. 1890–96. Ser. A.

Obituary Notice of Henry Phillips, Jr. (Proceedings of American Philosophical Soc., Memorial Volume 1, p. 26–35.)

Franklin, Benjamin, Writings. 10 v. 1905–07. Macmillan, N. Y.

American Literature. Philadelphia (Eldredge), 1889.

Pope's Homer's Iliad. 1899. Macmillan, New York.

Burke's Letter to a Noble Lord. 1898. Ginn and Co., Boston.

Syllabus of a course of six lectures on Shakespeare. (American Society for the Extension of University Teaching. University extension lectures, syllabi 1897–98.)

Halliwell-Phillipps Collection: An Address delivered before the Pennsylvania Library Club, January, 1895 in Pennsylvania Library Club occasional papers, No. 2. 1894—to date. (Free Library of Philadelphia.)

Benjamin Franklin:—An oration delivered in Paris April 27, 1906—on "Bi-Centenary of the Birth of Benjamin Franklin." Paris 1906.

Daniel G. Brinton:—An address—delivered before the American Philosophical Society. Jan. 16, 1900. (Proceedings of American Philosophical Society Memorial Vol. 1., pp. 221, etc.)

A "Franklin's Autobiography" with notes was Professor Smyth's last piece of work,—it is to be published in the Gateway Series edited by Henry Van Dyke.